Synthesis of Radio Telemetry, Hydroacoustic, and Survival Studies of Juvenile Salmon at John Day Dam (1980-2000)

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September 2001

Prepared for
the U.S. Army Corps of Engineers
Portland, Oregon

Battelle
. . . Putting Technology To Work

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(a) BioAnalysts, Inc.

Executive Summary

The Portland District of the U.S. Army Corps of Engineers requested that scientists from Battelle and BioAnalysts, Inc., review and synthesize the fisheries research conducted at John Day Dam between 1980 and 2000. Battelle and BioAnalysts reviewed 27 reports prepared for the Corps describing research conducted using radio-telemetry and hydroacoustic technologies to evaluate the downstream passage of juvenile salmon through the John Day Dam.

We were asked to 1) summarize fish behaviors including forebay approach patterns, residence times, and horizontal distribution of passage; 2) summarize fish passage efficiency and effectiveness; 3) identify uncertainties, limitations, and gaps in the data; and 4) provide recommendations for addressing these deficiencies in the data.

Results from the radio telemetry and hydroacoustic studies conducted at John Day Dam between 1980 and 2000 are summarized in Tables S.1, S.2, and S.3 and discussed below.

Fish Behavior

Radio-telemetry conducted upstream of John Day Dam indicated that steelhead and yearling chinook salmon typically migrated along the northern (Washington state) shoreline of the river. Both species also avoided the plume from the John Day River (which enters the Columbia from the south above the dam) suggesting either avoidance or being pushed to the north shore by the discharge. Summer migrants (sub-yearling chinook salmon) were typically distributed along both the north and south shorelines as they approached the dam and appeared to be less affected by discharge from the John Day River.

Data related to location of first entry into the John Day Dam forebay appeared mixed. Results from research conducted in 1995-1997 suggest first entry location may be a function of project discharge (i.e., fish approach the structure where the most discharge is occurring). However, in 1998 powerhouse passage remained high even with relatively high levels of spill discharge. Differences between the 1995-97 results and the 1998 results may be related to differences in study design, river/test conditions, and behavior of fish.

In general, yearling chinook salmon and steelhead that arrived in the forebay when no spill occurred tended to delay. Yearling chinook salmon and steelhead that arrived at night, concurrent with spill, passed the dam more readily. With respect to daytime spill, residence times of yearling chinook salmon were markedly reduced, whereas steelhead residence times decreased only slightly in the presence of daytime spill. When daytime spill went from 0 to 30% yearling chinook salmon residence time dropped from 8.5 h to 0.8 h in 1999 and 9.0 h to 2.4 h in 2000, while yearling steelhead residence time decreased from 11.4 to 11.3 h in 1999 and 11.4 to 9.4 h in 2000. Data collected in 1999 and 2000 suggest that hatchery steelhead (>200 mm) may delay in the John Day Dam forebay longer than wild steelhead (<200 mm).

Table S.1. Spill Efficiency, Spill Effectiveness, and Fish Passage Efficiency at John Day Dam Based on Radio Telemetry Studies Conducted in 1984 and 1995–2000. River discharge and spill volumes were for times the radio-tagged fish passed the project. (For 1999 and 2000 the numbers in parentheses are 95% confidence intervals.)

Species and Study Year	Sample Size	Sample Dates	SPE = % Fish Passing Spill	% Spill (ave) of Total Discharge	Spill Effectiveness	FPE = Fish Passage Efficiency	Spill Range (kcfs)	River Discharge Range (kcfs)
1984[a]								
CHIN 1	95	5/1-5/25	74	42	1.8:1	NA		260-370
1995[b]								
CHIN 1	100	5/2-6/8	24.5	3.9	6.3:1	NA	8-13	250-296
1996[c]								
CHIN 1	138	4/25-6/5	43.1	20.7	2.1:1	NA	47-125	298-450
CHIN 0	75	6/12-7/19	39.5	18.4	2.1:1	NA	55-56	225-359
1997[d]								
STH 1	122	4/28-6/9	54.6	33.0	1.7:1	NA	92-215	397-540
CHIN 1	115	4/28-6/9	64.2	33.0	1.9:1	NA	92-215	397-540
CHIN 0	95	7/2-7/22	49.6	19.9	2.5:1	NA	58-62	291-308
1998[e]								
STH 1	119	5/1-5/22	52.3	43.3	1.2:1	NA	150-223	292-468
CHIN 1	120	5/1-5/22	74.7	43.3	1.7:1	NA	150-223	292-468
CHIN 0	119	6/22-7/17	76.5	53.2	1.4:1	NA	116-141	208-302
1999[f]								
STH 1 (12-h)	138	5/7-5/29	44.9 (36.5-53.6)	00/45	1.6:1	94.2 (88.9-97.5)		253-367
STH 1 (24-h)	156	5/7-5/29	52.6 (44.4-60.6)	30/45	1.1:1	90.4 (84.6-94.5)		253-367
CHIN 1 (12-h)	154	5/7-5/29	52.6 (44.4-60.7)	00/45	3.0:1	82.5 (75.5-88.1)		253-367
CHIN 1 (24-h)	160	5/7-5/29	65.6 (57.7-72.9)	30/45	1.4:1	87.5 (81.4-92.2)		253-367
Pooled (12-h)	292	5/7-5/29	49.0 (43.1-54.9)	00/45		88.0 (83.7-91.5)		253-367
Pooled (24-h)	316	5/7-5/29	59.2 (53.5-64.6)	30/45		88.9 (84.9-92.2)		253-367
2000[g]								
STH 1 (12-h)	207	5/1-5/24	68.6 (61.8-74.9)	00/53	2.3:1	93.2 (88.9-96.3)		218-312
STH 1 (24-h)	237	5/1-5/24	73.4 (67.3-78.9)	30/53	1.4:1	88.2 (83.4-92.0)		218-312
CHIN 1 (12-h)	200	5/1-5/24	66.5 (59.5-73.0)	00/53	2.4:1	84.5 (78.7-89.2)		218-312
CHIN 1 (24-h)	258	5/1-5/24	82.6 (77.4-87.0)	30/53	1.4:1	89.9 (85.6-93.3)		218-312
Pooled (12-h)	407	5/1-5/24	67.6 (62.8-72.1)	00/53		88.9 (85.5-91.8)		218-312
Pooled (24-h)	495	5/1-5/24	78.2 (74.3-81.7)	30/53		89.1 (86.0-91.7)		218-312

(a) Giorgi et al. 1985.
(b) Sheer et al. 1997.
(c) Holmberg et al. 1997.
(d) Hensleigh et al. 1999.
(e) Liedtke et al. 1999.
(f) Hansel et al. 2000a.
(g) Beeman et al. 2000.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.
pooled = yearling steelhead and yearling chinook salmon combined.

Table S.2. Metrics and Sampling Characteristics of Fixed Aspect Hydroacoustic Studies Conducted in Summer from 1980 through 1987

Sampling Metric	Study Year						
	1980[(a)]	1981[(a)]	1983[(b)]	1984[(c)]	1985[(c)]	1986[(d)]	1987[(e)]
Performance/Passage Metrics							
Project FPE	NA	NA	NA	NA	NA	NA	NA
Spill efficiency (spring/summer)	NA	NA	0.39 spr. 0.40 sum.	0.38 sum.	0.21 spr.	0.32 sum.	0.23 sum.
Turbine fraction	NA	NA	0.63	0.58	0.67	NA	0.89
Spill effectiveness	NA	NA	0.79 spr. 1.04 sum.	0.76 sum.	0.75 spr.	1.04 sum.	1.3 sum.
Sampling dates	4/22-6/11	4/20-8/13	4/23-8/26	6/5-8/26	4/21-7/28	7/17-8/14	6/7-8/15
Sampling duration	0000-2300	1700-0500	2000-0600	2100-0500	2100-0500	2000-0500	2100-0500
Mean project discharge (ft^3/s)	259,188	263,447	257,501	233,233	186,423	150,238	118,793
Spill discharge fraction	0.08	0.19	0.33	0.30	0.38	0.30	0.18
Turbines sampled	2 of 16	3 of 16	7 of 16	6 of 16	6 of 16	7 of 16	6 of 16
Spill bays sampled	1 of 20	2 of 20	6 of 20	6 of 20	6 of 20	6 of 20	5 of 20
Run timing		Yes	Yes	Yes	Yes	Yes	Yes
Powerhouse Metrics							
Horizontal distributions	Yes	Yes	Yes	NA	NA	Yes	Yes
Vertical distributions	Yes	Yes	Yes	NA	NA	Yes	Yes
Spillway Metrics							
Horizontal distributions	NA	NA	Yes	NA	NA	Yes	NA
Vertical distributions	NA	NA	NA	NA	NA	NA	NA
Detection threshold (dB)	-50	-50	-47 and -50	-50	-50	-56	-55 spring, -59 summer
Detection modeling	?	?	?	?	?	Yes	Yes
Detectability corrected	No	No	No	No	No	No	No

(a) Magne, Nagy, and Maslen 1983.
(b) Magne, Nagy, and Maslen 1987.
(c) Magne, Bryson, and Nagy 1987.
(d) Kuehl 1987.
(e) Johnson and Wright 1987.

Table S.3. Metrics and Sampling Characteristics of Fixed Aspect Hydroacoustic Studies Conducted in Summer from 1988 through 2000

Sampling Metric	Study Year						
	1988	1989	1996[(a)]	1997[(b)]	1998[(c)]	1999[(d)]	2000[(e)]
Performance/Passage Metrics							
Project FPE	NA	NA	NA	NA	NA	NA	NA
Spill efficiency (spring/summer)	0.19 sum.	0.28 sum	NA	0.53 spr./ 0.85 sum.	0.63 spr./ 0.49 sum.	0.82 spr./ 0.93 sum.	0.79 sum.
Turbine fraction (spring/summer)	0.90	0.86	NA	0.49 spr./ 0.19 sum.	0.34	0.18 spr./ 0.07 sum.	0.21
Spill effectiveness (spring/summer)	1.1 sum	1.4 sum	NA	2.32 spr./ 3.92 sum.	2.92 spr./ 1.89 sum.	2.74 spr./ 3.76 sum.	2.79 sum.
Sampling dates	5/13-8/15	6/11-8/23	5/8-7/23	5/5-7/24	4/19-7/18	5/1-7/8	6/6-7/9
Sampling duration	2100-0500	2000-0600	0000-2300	0000-2300	0000-2300	0000-2300	0000-2300
Mean project discharge (ft^3/s)	142,086	119,249	335,947	486,676	283,387	313,225	195,324
Spill discharge fraction	0.18	.21	0.21	0.35	0.32	0.27	0.36
Turbines sampled	6 of 16	6 of 16	1 of 16	8 of 16	8 of 16	15 of 16	16 of 16
Spill bays sampled	4 of 20	6 of 20	0 of 20	10 of 20	11 of 20	11 of 20	11 of 20
Run timing	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Powerhouse Metrics							
Horizontal distributions	Yes	Yes	NA	Yes	Yes	Yes	Yes
Vertical distributions	Yes	Yes	NA	Yes	Yes	Yes	Yes
Spillway Metrics							
Horizontal distributions	NA	Yes	NA	Yes	Yes	Yes	Yes
Vertical distributions	NA	Yes	NA	Yes	Yes	Yes	Yes
Detection modeling	Yes	Yes	?	Yes	Yes	Yes	Yes
Detectability corrected?	No	No	No	No	No	No	Yes

(a) BioSonics 1996.
(b) BioSonics 1999a.
(c) BioSonics 1999b.
(d) Johnston, Nealson, and Horchik 2000.
(e) Moursund et al. 2001.

Fish Passage Efficiency and Effectiveness

Diel behavioral responses (species specific) to dam operating conditions made it difficult to detect differences in fish passage efficiency (FPE) at John Day Dam. Radio-tagged fish, especially steelhead arriving at the dam during 0 or 30% day spill conditions, almost always delayed passing until night. Therefore, with the great majority passing at night the sample sizes for day FPE or spill passage efficiency (SPE) estimates are very low and the day metrics are difficult to interpret.

From 1984 through 1998, based on radio-telemetry, a general comparison may be made for SPE and spill effectiveness, when spill percent was similar (ranging from ~33-43%). Both SPE and spill effectiveness varied little among years, seasons, or species, with SPE ranging from 52% for yearling steelhead in the spring of 1998 to 77% for subyearling chinook salmon in the summer of 1998, with an overall average of about 60%.

Radio-telemetry and hydroacoustics results were similar for the 12-h versus 24-h spill tests conducted in 1999 and 2000 at John Day Dam. We conclude that the use of 24-h spill slightly increases the SPE for steelhead and yearling chinook salmon, but does not substantially improve FPE for either species compared to the 12-h spill. In both years, SPE based on hydroacoustics was approximately 93% for 30% spill days and 63% for no spill days. Even though the addition of day spill (24-h spill) did not improve FPE, it was beneficial to both steelhead and juvenile chinook salmon by reducing their forebay residence times which may have benefits for fitness and survival. Higher spill at night in 2000 (53%) compared to 1999 (45% spill) accounted for SPEs that were 14% to 27% greater in 2000, based on radio-telemetry.

Data Limitations

The lack of statistical rigor in most fish passage evaluations precludes the use of much of the radio-telemetry and hydroacoustic data collected over the years at John Day Dam. Much of the early work focused on evaluating the efficacy of a sampling technique or monitoring trends in fish passage. Only within the last couple of years have research efforts been directed at determining route-specific survival and fish passage efficiencies.

Due to the relatively low numbers of tagged fish released, daily or perhaps even weekly estimates of passage are unavailable for the majority of years. Sample sizes of radio-tagged juveniles were only large enough to discern differences in forebay residence time during spill tests and diel periods in 1999 and 2000.

Changes in transducer placement and type, along with changes in analyses procedures, limit the comparability of fish passage efficiency metrics from year to year. Refinements in transducer analyses procedures and deployments, which have occurred over the last three years, have provided researchers with passage estimates appropriate for evaluating differences in fish passage among treatments and years for those years.

Data related to survival of juvenile salmon passing through John Day Dam to date are too sparse to even generally characterize passage impacts.

Recommendations

A general recommendation for concurrent radio-telemetry and hydroacoustic research activities at John Day Dam is to coordinate study designs where practical so resulting data can be cross-checked and integrated.

We recommend that sample sizes of tagged fish for future radio-telemetry research be large enough to detect significant differences among key passage and behavior metrics. Improvements in tag detection by underwater antenna arrays are recommended. We also recommend that radio-telemetry data collection and analyses protocols be standardized.

For the hydroacoustic aspect of fish passage evaluations, we recommend methods used in 2000 become a starting point for future fish passage studies at John Day Dam. Detectability modeling using empirical data on parameters such as fish trajectory, fish speed, and target strength for each unique location is recommended. The standardization effort initiated by the District in 2001 is an important step in refining analyses and processing techniques that will then provide for comparability in future years.

With respect to survival estimates, we recommend that the District continue evaluating project, dam, and route-specific survival techniques to perfect methods for use at John Day Dam forebay and tailrace as a whole.

The review of the radio-telemetry and hydroacoustic research conducted at John Day Dam from 1980-2000 does not readily yield clear-cut results or relationships between fish passage and project operations. It is apparent that substantial advancements have been made in both fields and research conducted currently and in the last half-decade has become more rigorous as defined questions and uncertainties have arisen. Our review of the selected studies suggests that current research efforts at John Day Dam should focus on determining route-specific estimates of survival. If survival through the project or dam is acceptable, then additional specific information on spillway passage efficiency and vertical distribution may not be necessary.

Acknowledgments

We sincerely acknowledge the cooperation, assistance, and dedication of the following persons:

- Mike Langeslay of the U.S. Army Corps of Engineers, Portland District and the reviewers who provided comments.
- John Beeman and Hal Hansel (USGS at the Columbia River Research Laboratory) for providing reports (in various stages) and unpublished information.
- Bruce Ransom of Hydroacoustic Technology Inc. for providing published data in electronic format.
- Brian McFadden of BioSonics Inc. for providing published data in electronic format.
- Kenneth Ham of Battelle for providing unpublished data in electronic format.

Acronyms and Abbreviations

ACE	U.S. Army Corps of Engineers
BRZ	boat restricted zone
CHIN 0	subyearling chinook salmon
CHIN 1	yearling chinook salmon
DSP	Digital Spectrum Processors
ft	ft
FGE	Fish Guidance Efficiency
FPE	Fish Passage Efficiency
h	hour
JDA	John Day Dam
kcfs	thousand cubic feet per second
km	kilometer
NMFS	National Marine Fisheries Service
PSC	prototype surface collector
Q	river discharge
SMP	Smolt Monitoring Program
SPE	Spill Passage Efficiency
STH 1	yearling steelhead
STS	submerged traveling screens
USGS	U.S. Geological Survey

Contents

Figures

Tables

1.0 Introduction

Understanding fish passage distribution and survival rates through spillways, turbines, bypass systems, and sluiceways under various dam operating conditions is critical for managing hydroelectric projects for fish passage. Juvenile fish passage at John Day Dam has been studied extensively over the last two decades using a variety of radio telemetry, hydroacoustic, and mark recapture techniques. However, annual reports by different investigators have never been summarized to identify concordant and divergent results, and common passage metrics among years have not been compared. Thus, a thorough synthesis of existing annual reports is needed to provide regional fisheries managers with the current state of knowledge regarding fish passage at John Day Dam.

To help meet this need, the Portland District, U.S. Army Corps of Engineers (Corps), asked Battelle and BioAnalysts Inc. to summarize and synthesize results from existing reports on juvenile salmon and steelhead passage research and monitoring conducted for the Corps at John Day Dam between 1980 and 2000.

1.1 Scope and Objectives

We reviewed and summarized 27 publications on radio telemetry, hydroacoustic, and survival studies of juvenile salmon at John Day Dam conducted between 1980 and 2000. Table 1.1 lists these reports by study type, authors, and year published. Appendix A briefly summarizes each of the publications reviewed.

Our objectives in reviewing these publications were to

- summarize forebay approach patterns, residence times, and horizontal distribution of passage
- summarize tailrace egress results
- summarize spill passage efficiency and effectiveness results
- provide a general review of survival results
- discuss limitations of data and sampling techniques
- recommend standard ways of collecting, examining, and archiving data
- identify key uncertainties and critical data gaps

Table 1.1. Reports Reviewed for John Day

Authors	Year Published	Title
Fixed-Location Hydroacoustics		
Moursund et al.	2001	Hydroacoustic Evaluation of Downstream Fish Passage at John Day Dam in 2000
Johnston, Nealson, and Horchik	2000	Hydroacoustic Studies at John Day Dam During Spring and Summer 1999
Ploskey and Carlson	1999	Comparison of Hydroacoustic and Net Estimates of Fish Guidance Efficiency of an Extended Submersible Bar Screen at John Day Dam
BioSonics, Inc.	1999b	Hydroacoustic Study at John Day Dam, 1998
BioSonics, Inc.	1999a	Hydroacoustic Evaluation and Studies at John Day Dam, Spring 1997, Appendices 1-6
BioSonics, Inc.	1996	Estimation of Guidance Efficiency of an Extended Bar Screen at John Day Dam by Hydroacoustic Techniques
McFadden and Hedgepeth	1990	Hydroacoustic Evaluation of Juvenile Salmon Fish Passage at John Day Dam in Summer 1989
Ouellette	1988	Hydroacoustic Evaluation of Juvenile Salmon Fish Passage at John Day Dam in Summer 1988
Johnson and Wright	1987	Hydroacoustic Evaluation of the Spill Program for Fish Passage at John Day Dam in 1987
Kuehl	1987	Hydroacoustic Evaluation of Juvenile Salmon Fish Passage at John Day Dam in Summer 1986
Magne, Bryson, and Nagy	1987	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmon at John Day Dam, 1984-1985
Magne, Nagy, and Maslen	1987	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmon at John Day Dam in 1983
Magne, Nagy, and Maslen	1983	Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmon at John Day Dam, 1980-1981
Radio Telemetry		
Beeman et al.	2000	Estimates of Fish and Spill Passage Efficiency of Radio-Tagged Juvenile Steelhead and Yearling Chinook Salmon at John Day Dam, 2000
Duran et al.	2000a	Movement, Distribution and Behavior of Radio-Tagged Juvenile Subyearling Chinook Salmon in the Tailrace of John Day Dam, 2000
Duran et al.	2000b	Movement, Distribution and Behavior of Radio-Tagged Juvenile Subyearling Chinook Salmon in the Tailrace of John Day Dam, 2000
Giorgi et al.	1985	Smolt Passage Behavior and Flow-Net Relationship in the Forebay of John Day Dam
Hansel et al.	1995	Movements and Distributions of Radio-Tagged Northern Squawfish Near The Dalles and John Day Dams
Hansel et al.	2000a	Estimates of Fish and Spill Passage Efficiency of Radio-Tagged Juvenile Steelhead and Yearling Chinook Salmon at John Day Dam, 1999

Table 1.1. (contd)

Authors	Year Published	Title
Hansel et al.	2000b	Movement, Distribution, and Behavior of Radio-Tagged Subyearling Chinook Salmon in the Forebay of John Day Dam, 1999
Hensleigh et al.	1999	Movement, Distribution, and Behavior of Radio-Tagged Juvenile Chinook Salmon and Steelhead in John Day, The Dalles and Bonneville Dam Forebays, 1997
Holmberg et al.	1997	Movement, Distribution, and Behavior of Radio-Tagged Juvenile Chinook Salmon in John Day, The Dalles, and Bonneville Dam Forebays, 1996
Liedtke et al.	1999	Movement, Distribution, and Behavior of Radio-Tagged Juvenile Salmon at John Day Dam, 1998
Sheer et al.	1997	Movement and Behavior of Radio-Tagged Juvenile Spring and Fall Chinook Salmon in The Dalles and John Day Dam Forebays, 1995
Shively, Sheer, and Holmberg	1995	Description and Performance of an Automated Radio Telemetry System to Monitor the Movement and Distribution of Northern Squawfish at Columbia River Dams
Snelling and Schreck	1995	Movement, Distribution, and Behavior of Juvenile Salmon Passing through Columbia and Snake River Dams
Survival		
Counihan et al.	2000	Feasibility of Extracting Survival Information from Radio Telemetry Studies at the John Day Dam

- recommend evaluations to address these gaps

- assess potential for reanalyzing existing data to glean additional information with management implications.

1.2 Background and Overview

Applications of radio-telemetry and hydroacoustics in the early 1980s were primarily feasibility studies. Early success using tagged fish indicated that juvenile salmon could be tracked as they approached and passed through the John Day Dam powerhouse and spillway. Reductions in tag size along with improvements in monitoring hardware have allowed researchers to tag smaller fish and track multiple tags simultaneously. The technological advances have allowed researchers to describe specific routes of passage (i.e., Turbine 16) as opposed to general passage routes (north powerhouse). Hydroacoustic technology has undergone similar advances with improvements in hardware and software allowing researchers to more readily determine direction of movement and to discern fish from debris-generated traces.

Battelle and BioAnalysts were asked to evaluate the validity of results from the hydroacoustic and radio telemetry studies conducted at John Day Dam over the past 20 years in light of these advances and to identify inconsistencies in reporting among investigators that prevented comparisons of data on a finer scale. Battelle and BioAnalysts were also asked to identify critical information gaps and recommend evaluations to address these. These data gaps are identified in Tables 1.2 and 1.3.

The focus of many of the past studies involved determining the distribution of fish passage among routes through the dams. Common metrics used to describe fish passage at John Day Dam are listed below. These metrics are listed in this report for study years where data were sufficient to provide them.

- Spill Passage Efficiency (SPE) – the proportion of total fish passing the project that pass through the spillway.

- Spill Passage Effectiveness – SPE divided by the proportion of total discharge going over the spillway.

- Fish Passage Efficiency (FPE) – the proportion of fish that pass through non-turbine routes i.e., juvenile bypass system and spillway.

- Fish Guidance Efficiency (FGE) – the proportion of powerhouse-entrained fish that are guided into bypass systems.

1.3 Report Contents

Chapter 2 of this report describes John Day Dam's spill operations and salmon run compositions during the study periods. Chapter 3 describes fish passage behavior, specifically forebay approach, residence time, horizontal distribution, tailrace egress, and predation. Chapter 4 summarizes results from the radio telemetry and hydroacoustic studies. Chapter 5 describes the limited data on survival at John Day Dam. Chapter 6 discusses limitations, uncertainties and inconsistencies in the radio telemetry, hydroacoustic, and survival data reviewed. Chapter 7 provides conclusions and recommendations, as requested by the Corps. Chapter 8 lists references. Appendix A is an annotated bibliography of the 27 reports we reviewed.

Table 1.2. Data Availability of Radio Telemetry Fisheries Data for John Day Dam by Study Year

Data Type	Study Year									
	1983[(a)]	1984[(a)]	1993[(b)]	1994[(c)]	1995[(d)]	1996[(e)]	1997[(f)]	1998[(g)]	1999[(h)]	2000[(i)]
Performance/Passage Metrics										
Fish passage efficiency	□	■	□	□	⊡	□	□	□	■	■
Spill passage efficiency	■	■	□	□	■	■	■	■	■	■
Spill passage effectiveness	■	■	□	□	■	■	■	■	■	■
Passage route	■	■	□	□	■	■	■	■	■	■
Forebay Metrics										
Forebay approach – downriver	■	■	□	□	■	■	■	□	□	□
Forebay approach – downriver near dam	⊡	⊡	□	□	■	■	■	■	■	■
Forebay horizontal distribution	□	□	□	□	■	■	■	■	□	□
Forebay residence time	(j)	(j)	□	□	■	■	■	■	■	■
Tailrace Metrics										
Tailrace egress route	□	□	■	⊡	□	⊡	□	■	■	■
Tailrace egress residence time	□	□	■	⊡	□	⊡	□	■	■	■
Tailrace predator distribution	□	□	■	■	□	□	□	□	□	□
Probable predation events	□	□	⊡	⊡	⊡	⊡	□	■	⊡	□
Survival Metrics										
Survival PIT tag	□	□	□	□	□	⊡	⊡	⊡	⊡	⊡
Survival radio telemetry	□	□	□	□	□	□	□	□	⊡	⊡

(a) Giorgi et al. 1985.
(b) Snelling and Schreck 1995.
(c) Hansel et al. 1995.
(d) Sheer et al. 1997.
(e) Holmberg et al. 1997.
(f) Hensleigh et al. 1999.
(g) Liedtke et al. 1999.
(h) Hansel et al. 2000a&b.
(i) Beeman et al. 2000; Duran et al. 2000a&b.
(j) Residence times stated in this study are not comparable with residence times stated in the other reports because they included time taken by fish to travel from release site to forebay, not time in forebay only.

■ = The study provided this data. □ = The study did not provide this data. ⊡ = Information provided in report was qualitative not quantitative.

Table 1.3. Data Availability for Hydroacoustics Studies at John Day Dam by Study Year

Sampling Metric	Study Year													
	1980[a]	1981[a]	1983[b]	1984[c]	1985[c]	1986[d]	1987[e]	1988[f]	1989[g]	1996[h]	1997[i]	1998[ja]	1999[k]	2000[l]
Performance/Passage Metrics														
Fish passage efficiency	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Spill passage efficiency	□	□	■	□	□	□	■	■	■	□	■	■	■	■
Turbine fraction	□	□	■	■	■	■	■	■	■	□	■	■	■	■
Spill passage effectiveness	□	□	■	■	■	■	■	■	■	□	■	■	■	■
Run timing	□	■	■	■	■	■	■	■	■	■	■	■	■	■
Powerhouse Metrics														
Horizontal distributions	■	■	■	□	□	■	■	■	■	□	■	■	■	■
Vertical distributions	■	■	■	□	□	■	■	■	■	□	■	■	■	■
Temporal distributions	■	■	■	□	□	■	■	■	■	□	■	■	■	■
Spillway Metrics														
Horizontal distributions	□	□	■	□	□	■	□	□	■	□	■	■	■	■
Vertical distributions	□	□	□	□	□	□	□	□	■	□	■	■	■	■
Temporal distributions	□	□	□	□	□	□	■	■	■	□	■	■	■	■

(a) Magne, Nagy, and Maslen 1983.
(b) Magne, Nagy, and Maslen 1987.
(c) Magne, Bryson, and Nagy 1987.
(d) Kuehl 1987.
(e) Johnson and Wright 1987.
(f) Ouellette 1988.
(g) McFadden and Hedgepeth 1990.
(h) BioSonics 1996.
(i) BioSonics 1999a.
(j) BioSonics 1999b.
(k) Johnston, Nealson, and Horchik 2000.
(l) Moursund et al. 2001.
■ = The study provided this data. □ = The study did not provide this data.

2.0 Environmental Setting

John Day Dam, located at Columbia River mile 215.6 (Figure 2.1), includes a navigation lock, a spillway with 20 bays (numbered north to south), and a 1,975-feet (ft)-long powerhouse comprised of 16 turbines and 4 skeleton bays (Figure 2.2). Turbines bays are numbered 1 to 20 from south to north. Standard length submerged traveling screens are in all units, with a juvenile fish facility located on the Oregon shore. Each turbine unit is divided into three intakes, identified as A, B, and C, beginning from the north.

Figure 2.1. The Location of John Day and Other Dams on the Columbia River

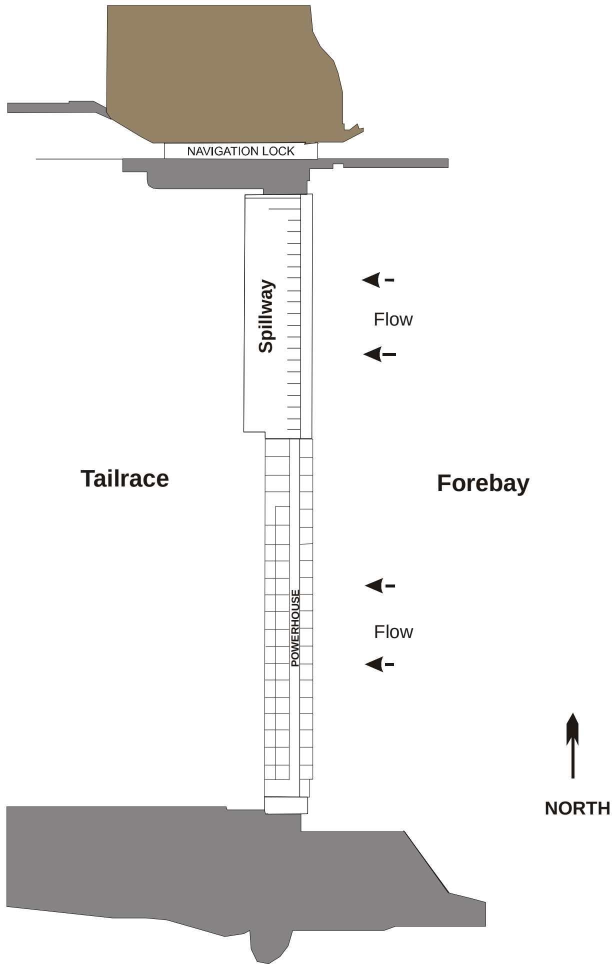

Figure 2.2. Plan View of John Day Dam

2.1 Project Operations for Fish

We reviewed radio telemetry and hydroacoustic reports from 1980 to 2000 to evaluate project operations related to fish passage. From 1980 to 1989, spill passage was evaluated as an alternative route for bypassing downstream migrants. During this period, when daily passage estimates exceeded 30,000 fish, the project biologist would request spill. Spill was limited to nighttime periods (2000-0600 hours [h]) and typically occurred at higher numbered bays (15-20). During the nighttime spill window, spill discharge ranged from approximately 8% to 38% of project discharge.

From 1998 to 2000, tests were conducted to evaluate spillway passage at different levels of daytime and nighttime spill. In 1998 spillway passage was compared between days with and without daytime spill. Spill levels ranged between 20% and 30% during day and between 35% and 60% at night. In 1999 and 2000, spillway passage was compared between 0% and 30% daytime spill levels. Some fish passage did occur during 0% spill because the spill bay closest to the fish ladder was open to attract adult fish to the ladder. The target for nighttime spill was 60% for both years. Project operations resulted in actual nighttime spill percentages of 45% and 53% in 1999 and 2000, respectively.

2.2 Run Composition and Timing

Historically, the spring out migration of juvenile salmon past John Day Dam consists of yearling chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), coho salmon (*O. kisutch*), and sockeye salmon (*O. nerka*) and the summer outmiragtion period is dominated by subyearling chinook salmon (Figure 2.3). The average indexed run size from 1995 to 2000 is 1,064,224 for yearling chinook salmon, 1,690,595 for subyearling chinook salmon; 394,529 for coho salmon, 256,961 for sockeye salmon, and 939,987 for steelhead. Yearling chinook salmon typically migrate past John Day Dam from early April until late June, with the migration peak occurring in mid-May. The average coho salmon run begins on April 18, peaks on May 18, and ends on June 25. The average sockeye salmon run begins on April 25, peaks on May 14, and ends on June 26. The average steelhead run begins on April 10, peaks on May 16, and ends on June 19. The average subyearling chinook salmon run begins on May 26, peaks around June 30, and ends on September 10.

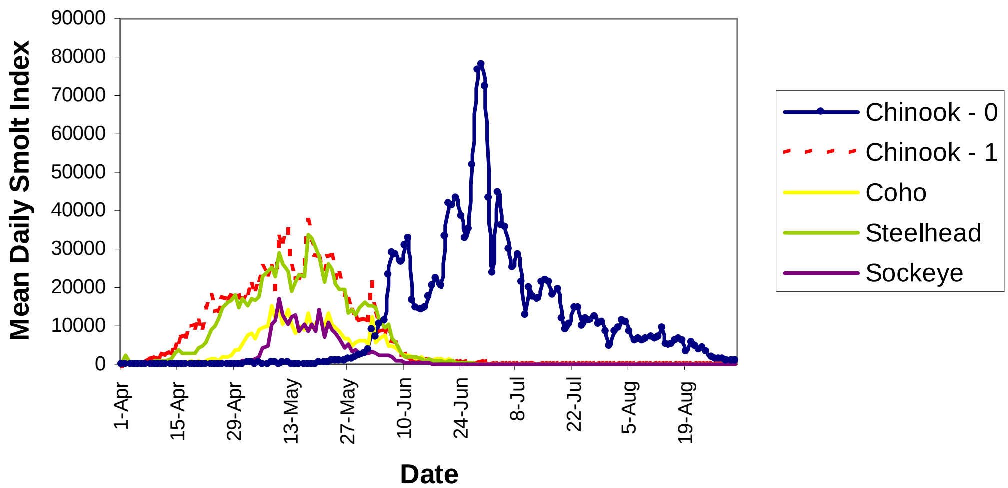

Figure 2.3. Run Timing for Salmon and Steelhead Smolts at John Day Dam. Data are expressed as the mean daily smolt index 1995-2000 from the Smolt Monitoring Program (SMP). Chinook salmon - 0 = sub-yearling *Oncorhynchus tshawytscha*; chinook salmon - 1 = yearling *O. tshawytscha*; Coho = yearling *O. kisutch*; Sockeye = yearling *O. nerka*; and Steelhead = juvenile *O. mykiss*.

3.0 Fish Behavior

Of the three Portland District projects, John Day Dam has the longest history of studies conducted to examine smolt migration and passage behavior. The tools and techniques that have been employed there since the mid 1970s have included gatewell dipping, fyke net sampling, hydroacoustic monitoring, radio telemetry monitoring, and smolt monitoring by the Smolt Monitoring Program. The goal for this section of the report is to describe the migration and passage behavior of juvenile salmon at John Day Dam as determined by radio telemetry.

We discuss the migration and passage behavior at John Day Dam in four categories: forebay approach, horizontal distribution, route of passage, and tailrace egress. Predator distribution and vulnerability of juvenile salmon to predation at the project are also included in a separate sub-section at the end of this section.

3.1 Forebay Approach

The approach of emigrating juvenile salmon into the forebay of a mainstem hydroelectric dam has important consequences as to how quickly and where juveniles pass through the project. By examining project operating conditions during the approach of radio-tagged juvenile salmon, it may be possible to determine the project configuration and operations that more efficiently and effectively pass fish.

We break down forebay approach into two components: 1) downriver migration routes taken by radio-tagged fish from a release site ~6 to 8 km upriver to about 100 m upstream of the dam, and 2) near-dam entry points/areas that are first entry locations of tagged fish into the near-field zone of the dam forebay, within 100 m of the dam.

The earliest studies that examined detailed passage behavior of juvenile salmon at John Day Dam using radio-tagged juvenile salmon took place from 1980 through 1984 and were conducted by the National Marine Fisheries Service (Sims et al. 1981; Faurot et al. 1982; Stuehrenberg and Liscom 1983; Giorgi and Stuehrenberg 1984a and 1984b; Giorgi et al. 1985). One of the major objectives of these studies was to determine the feasibility of radio telemetry as a tool for discerning the forebay approach of juvenile salmon. Studies examined whether various dam operating conditions affected the forebay approach routes of tagged juveniles (from a release site 6.3 km upriver) to the dam and specific routes of passage through the dam.

Initial efforts (Sims et al. 1981; Faurot et al. 1982) were primarily feasibility studies to test the radio telemetry tracking and monitoring techniques. They were able to track fish successfully from the release site to the forebay, although in 1981 (Faurot et al. 1982) they attempted to estimate spill efficiency at 2 spill levels, i.e., shallow vs. deep spill, and effectiveness of sequential load dropping. However, too few fish were tracked and too many test conditions were encountered to provide useful measures of spill efficiency and effectiveness.

Later, Giorgi et al. (1985) radio-tagged yearling chinook salmon (n=21) and steelhead (n=11) in 1983 and yearling chinook salmon (n=95) in 1984 and through mobile tracking determined that all fish moved downriver along the Washington shoreline side of the river from their release point 6.3 km above the dam. All chinook salmon juveniles appeared to avoid the plume of the John Day River and steelhead were less affected by the John Day river plume than chinook salmon. They also found that if fish entered the forebay restricted zone during the daytime (0800-2000 h), they tended to hold until dark before passing the dam (3 of 6 fish). If fish entered at night (2000-0700 h) they moved through the dam with little delay (2 of 2 fish). These studies were conducted when miniaturized radio tags were just being developed. Also, new monitoring techniques were being developed and sample sizes were small, thus only qualitative assessments could be made.

More recent radio telemetry studies of the migration and passage behavior of juvenile salmon at John Day Dam took place from 1995 through 2000 and were conducted by the U.S. Geological Survey (USGS) (Sheer et al. 1997; Holmberg et al. 1997; Hensleigh et al. 1999; Liedtke et al. 1999; Hansel et al. 2000; Beeman et al. 2000-Preliminary). The USGS studies were designed to determine forebay approach routes using mobile (boat) tracking to determine radio-tagged fish movements from the upriver release site down to near the dam (within 100 meters [m]). An array of fixed station receivers and antennas were mounted on the dam to detect specific areas where fish first entered the near dam zone, within 100 m of the dam.

In 1995 (Sheer et al. 1997), seven groups of radio-tagged yearling chinook salmon (n=100) were released 8 km above the dam from May 2 to June 8 (no mobile tracking was done for the June 8 release). Three groups moved downriver along the north (Washington) side of the river and three groups migrated more toward mid-channel. The seventh group moved downriver without any discernable trend. All avoided the John Day River plume. This observation was consistent with that reported by Giorgi et al. (1985). As fish entered the near dam zone (within ~100 m), which was monitored by the fixed station receivers, a high percentage of fish entered the south (40.6%) and north (27.5%) powerhouse areas (Table 3.1).

In the spring of 1996, using the same general study design, Holmberg et al. (1997), radio-tagged 138 yearling chinook salmon. Tracking results again showed that fish moved downriver along the Washington (north) side of the main channel and avoided the plume of the John Day River. As radio-tagged fish approached within ~100 m of the dam, they were fairly evenly dispersed and did not show any preference for entering the near field monitoring zone of fixed receivers at any particular area. In the summer of 1996, radio-tagged subyearling chinook salmon (n=75) also moved downriver from their release point along the north side of the main channel in the same manner as the yearlings. There was a slight preference for first entering the near field forebay (33%) in the area at the north end of the powerhouse (Table 3.1).

In 1997, radio-tagged steelhead (n=122) and yearling chinook salmon (n=115) were tracked downriver from the release site, mostly along the north shore and the north side of the main channel (Hensleigh et al. 1999). As the fish entered the near dam area, steelhead (~65%) and yearling chinook salmon (~70%) entered at the spillway area. In the summer, sub-yearling chinook salmon (n=95) were detected moving downriver along both the north and south shorelines above the dam, and sub-yearlings entered the near field zone somewhat evenly dispersed across the forebay (Table 3.1).

Table 3.1. Location of Radio-Tagged Juvenile Salmon at First Detection in the Near-Dam (<100 m) Forebay of John Day Dam (% by area), 1995-1998

	Sample Size	Percent of Fish First Detected				% Spill Average	Spill Range (kcfs)	River Discharge Range (kcfs)
		South Power-house	North Power-house	South Spill	North Spill			
1995[a]								
CHIN 1	100	42.0	27.5	17.4	13.0	3.9	8-13	250-296
1996[b]								
CHIN 1	138	20.5	26.8	22.3	30.4	20.7	47-125	298-450
CHIN 0	75	20.8	33.3	20.8	24.9	18.4	55-56	225-359
1997[c]								
STH 1	122	6.6	31.0	13.1	49.4	33.0	92-215	397-540
CHIN 1	115	2.0	27.0	18.1	52.9	33.0	92-215	397-540
CHIN 0	95	19.1	30.5	16.8	33.6	19.9	58-62	291-308
1998[d]								
STH 1	119	27.9	34.9	9.3	27.9	43.3	150-223	292-468
CHIN 1	120	14.7	31.6	13.7	40.0	43.3	150-223	292-468
CHIN 0	119	20.6	20.6	26.4	32.4	53.2	116-141	208-302

(a) Sheer et al. 1997.
(b) Holmberg et al. 1997.
(c) Hensleigh et al. 1999.
(d) Liedtke et al. 1999.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

The general study design changed somewhat in 1998 (Liedtke et al. 1999). The release site for the study was the McNary Dam juvenile bypass outfall, and unlike previous years, no mobile tracking in the reservoir was done, only fixed station monitoring in the near dam forebay ~100 m out from dam. In the spring, radio-tagged steelhead (n=119) and yearling chinook salmon (n=120) showed a slight preference for entering the near dam area in the north powerhouse zone. In summer, sub-yearling chinook salmon (n=119) were evenly dispersed as they entered the near dam area (Table 3.1).

In 1999, the USGS radio telemetry study design focused on determining spill and fish passage efficiency at John Day Dam during 12-h spill treatments and 24-h spill treatments (Hansel et al. 2000a). (A 12-h spill treatment implies spill at night only; hence 0% daytime spill; a 24-h spill treatment means spill during the day and night. Daytime spills during the 24-h treatment were 30% in 1999 and 2000. Night time spills were 45% of flow in 1999 and 53% of flow in 2000. No mobile tracking was done but detections of first entry into the near dam forebay were recorded for powerhouse and spillway (not broken down by north or south areas) (Table 3.2). Fifty-five percent of the steelhead first entered the near dam zone at the powerhouse and 45% entered at the spillway. First detections of steelhead did not vary much between the 12-h and 24-h spill treatments. For yearling chinook salmon, however, the 24-h spill treatment appeared to attract or draw 10% of the fish from the powerhouse area of the forebay to the spillway area

Table 3.2. Location of Radio-Tagged Juvenile Salmon (% by area) at First Detection in Forebay of John Day Dam during 12-h and 24-h Spill Treatments in 1999 and 2000

Species and Location	Percent of Fish First Detected			
	12-h Spill	24-h Spill		
1999[a]	0%Day/45%Night	30%Day/45%Night		
STH 1 (n=479)				
Powerhouse	55%	53%		
Spillway	45%	47%		
CHIN 1 (n=469)				
Powerhouse	49%	39%		
Spillway	51%	61%		
1999[b]	0 Spill Day	Low spill day	Low spill night	High spill night
CHIN 0 (n=298)				
Powerhouse	91%	68%	54%	19%
Spillway	9%	32%	46%	81%
2000[c]	0%Day/53%Night	30%Day/53%Night		
STH 1 (n=487)				
Powerhouse	29%	28%		
Spillway	71%	72%		
CHIN 1 (n=484)				
Powerhouse	47%	35%		
Spillway	53%	65%		

(a) Hansel et al 2000a.
(b) Hansel et al. 2000b.
(c) Beeman et al. 2000.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

of the forebay. Also in 1999, subyearling chinook salmon were widely dispersed upon first entry into the near dam forebay, and comparisons between 12-h and 24-h spill treatments were difficult to interpret due to changing levels of percent night-time spill among blocks (Hansel 2000b). The results are seen in Table 3.2.

In 2000 (Beeman et al. 2001 – Preliminary) the same basic study design was applied with 12-h and 24-h spill treatments tested as in 1999. Both steelhead and yearling chinook salmon first entered the near dam zone in considerably higher numbers in the spillway area than in the powerhouse area during all spill test conditions (Table 3.2).

Several consistent behavior patterns of approach by juvenile salmon into the forebay of John Day Dam are apparent from available data from radio telemetry studies conducted over the past 17 years. These patterns fall into two categories: 1) forebay approach from upriver and 2) first entry into the near dam zone (within 100 m).

3.1.1 Forebay Approach from Upriver

Migration from release sites 6 to 8 km up river, as determined by boat mobile tracking, indicate that the great majority of spring migrants (yearling chinook salmon and steelhead) move downriver along the Washington shoreline or along the more northern portion of the main channel. When in the area of the John Day River plume it appears that there is a strong response to avoid the plume and fish will go north toward the Washington shore to avoid it. An alternative explanation could be that the northerly trajectory of the plume could be directing fish to the north. Data describing plume current direction and intensity is lacking, so distinguishing between the competing theories is not possible. Summer migrants (subyearling chinook salmon) move downriver closer to the shorelines and often along both north and south shores. Usually by the time they arrive at the John Day River, the plume has dissipated and it appears to have little effect on their migration route. In 1996, however, the plume was still fairly strong and when radio-tagged subyearlings reached the plume they avoided it and moved north toward the Washington shore.

3.1.2 Near Dam First Entry

Project operations appear to have an important effect on where juvenile salmon first approach the dam. The data in Table 3.1 indicate that as volume of spill discharge increased from 1995 to 1997 the percentage of juvenile salmon, both yearlings and subyearlings, shifted from first entering at the powerhouse areas to entering in higher proportions at the spillway areas. In 1998, even though spill discharge was higher than in 1997, the percentages of both yearling and subyearlings first entering the spillway area dropped off somewhat. In 1999, during 12-h and 24-h spill tests, steelhead and yearling chinook salmon were first detected in about equal percentages at the powerhouse and spillway, regardless of test. For subyearlings in 1999, however, there was a strong positive relationship between spill percentage and percentage of fish first entering in the spillway area (Table 3.2). In 2000 a higher proportion of steelhead and yearling chinook salmon first entered at the spillway area regardless of test treatment.

3.2 Residence Time

The amount of time juvenile salmon spend in the forebay prior to passing the dam may be significant to their future condition and survival for several reasons: 1) delay in emigration disrupts life history synchrony (i.e., smolts may reach the estuary past their developmental peak or be too late in reaching the estuary for optimal food source availability in the littoral ocean waters), 2) fatigue because of wasted energy in searching and milling behavior can lead to stress, 3) fatigue and stress will increase risk of predation due to reduced predator avoidance capacity (Mesa 1994), and 4) increased forebay residence time increases prey density in the forebay, which will attract predators.

The first information available that examined the relationship between time of arrival and time and route of passage at John Day Dam was in 1983 (Giorgi et al. 1985), but sample sizes were very small.

Three of 6 fish arriving during the day held until night and then passed. Two of 2 fish entering during the night passed the dam without delay. In 1984 the same trend occurred. Fish arriving during the day held until dusk before passing.

The USGS studies, beginning in 1995 (Sheer et al. 1997) defined residence time as the mean or median time a smolt spends in the forebay from time of first entry into the near-dam area (~100 m) until passage. Table 3.3 shows near-dam forebay residence times for the USGS radio telemetry studies from 1995-1998 (Sheer et al. 1997; Holmberg et al. 1997; Hensleigh et al. 1999; Liedtke et al. 1999).

Table 3.3. Residence Times of Juvenile Salmon in John Day Dam Forebay, 1995-1998

	Sample Size	River Discharge (kcfs)	Spill (kcfs)	% Spill Average	Residence Time (h)
			1995		
CHIN 1	100	250-296	8-13	3.9	5.5 median
			1996		
CHIN 1	138	298-450	47-125	20.7	0.8 median
CHIN0	75	225-359	55-56	18.4	2.3 median
			1997		
STH 1	122	397-540	92-215	33.0	0.5 median
CHIN 1	115	397-540	92-215	33.0	0.3 median
CHIN 0	95	291-308	58-62	19.9	3.0 median
			1998		
STH 1	119	292-468	150-223	43.3	8.9 median
CHIN 1	120	292-468	150-223	43.3	1.8 median
CHIN 0	119	208-302	116-141	53.2	8.8 median

(a) Sheer et al. 1997.
(b) Holmberg et al. 1997.
(c) Hensleigh et al. 1999.
(d) Liedtke et al. 1999.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

Studies on diel patterns of arrival time and time of passage were conducted in 1999 and 2000 during 12-h and 24-h spill tests at John Day Dam (Hansel et al. 1999; Beeman et al. 2000). Median forebay residence times for these studies are shown in Table 3.4. Daytime spill was 0% for the 12-h treatment and 30% for the 24-h treatment. Nighttime spill was 45% in 1999 and 53% in 2000.

Table 3.4. Median Forebay Residence Times (in hours) of Radio-Tagged Juvenile Salmon by Time of Arrival (day or night), 1999 and 2000

1999[(a)]	00/45 Day	30/45 Day	00/45 Night	30/45 Night
STH 1 (n=275)	11.4	11.3	0.3	0.5
CHIN 1 (n=293)	8.5	0.8	0.2	0.3
1999[(b)]	0 Spill Day	Low Spill Day	Low Spill Night	High Spill Night
CHIN 0 (n=298)	4.3	5.2	2.5	0.6
2000[(c)]	00/53 Day	30/53 Day	00/53 Night	30/53 Night
STH 1 (n=487)	11.4	9.4	0.6	0.7
CHIN 1 (n=484)	9.0	2.4	0.5	0.6

(a) Hansel et al 2000a.
(b) Hansel et al. 2000b.
(c) Beeman et al. 2000.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

The earlier radio telemetry studies (1983, and 1995 through 1998) had neither the sample size, study design, or specific test conditions to answer questions of how project operating conditions affected the residence time juvenile salmon experienced at a project before passing. The major trends from these studies were that yearling chinook salmon had consistently lower residence times than both steelhead and subyearling chinook salmon. In 1999 and 2000, however, the sample sizes were large enough and monitoring extensive enough to learn that the project spill volume and diel period that a juvenile salmonid encountered when arriving in the near dam forebay would influence how long a fish would reside there before passing the dam. As seen in Table 3.4, the median residence times for juvenile steelhead arriving during 0% or 30% day spill were significantly longer than those for fish arriving during 45% (1999) or 53% (2000) night spill (Kruskal-Wallis tests, P<0.001). Results for yearling chinook salmon were similar to steelhead except they had significantly shorter residence times than steelhead during the 30% day spill condition. The results from 1999 and 2000 indicate that providing day spill decreases the forebay residence times of spring migrants arriving during the day, especially for yearling spring chinook salmon. Data for subyearling chinook salmon are equivocal, as fish arriving during the day delay passing with or without spill. Results for both years also indicate that if fish arrive at the dam at night, they readily pass the dam regardless of species or type.

An interesting result which is not seen in the above Table 3.4 but was reported in the text in both the 1999 and 2000 reports (Hansel et al. 1999 and Beeman et al. 2000) was that median forebay residence times for steelhead >200 mm (presumably hatchery smolts, the cutoff size for separation of hatchery from wild steelhead which were smaller than 200 mm) were considerably (about two to three times) longer than steelhead <200 mm. It is unknown whether this may have been due to behavioral differences or size and swimming performance differences.

Future studies are needed to help determine the consequences of the sometimes extended forebay residence times for juvenile salmonids. If this passage delay indeed results in increased indirect mortality, is the level of mortality significant or can a relationship between mortality and residence time be established? Radio telemetry survival studies and predator monitoring studies may be designed to provide some of those answers.

3.3 Horizontal Distribution

The horizontal distribution of juvenile salmon in the near-dam forebay may be a key to where fish ultimately pass the dam and could give insight on how to better configure and operate the project to more efficiently and effectively pass fish. Knowing the horizontal distribution may also indicate where to locate new fish passage collection facilities such as surface bypass systems.

In 1983 and 1984 Giorgi et al. (1985) noted that the juvenile migrants were predisposed to spill passage by virtue of their lateral distribution across the forebay. Fish were generally concentrated in the forebay on the Washington side of the river where the spillway is located. The authors did however indicate that fish arriving during the day prior to spill often redistributed themselves in front of the powerhouse and delayed passing the dam. These observations were based on the tracking of individual fish, thus sample sizes were very small.

From 1995 to 1998, the USGS determined the horizontal distribution of juvenile salmon in the near dam forebay by monitoring for tagged fish/transmitters with an array of aerial antennas capable of detecting transmitters within 100 m of the dam. The antennas were attached to data-logging receivers positioned along the periphery of the forebay. Each time a tagged fish was recorded from a zone monitored by a specific antenna it was counted as one observation for that zone/location. The distribution of observations was considered to be the horizontal distribution of fish in the near-dam forebay.

From 1995 through 1998, the majority of observations of radio-tagged juvenile salmon were concentrated at the south end of the powerhouse (Sheer et al. 1997; Holmberg et al. 1997; Hensleigh et al 1999; Liedtke et al. 1999) (Table 3.5). Individual fish records indicate that most of the fish were recorded in more than one zone in the forebay, indicating lateral movements or “milling” behavior in the near dam forebay, similar to what Giorgi et al. (1985) observed. Horizontal distribution was not measured at John Day Dam in 1999 and 2000.

As seen in Table 3.5, it is apparent that, as the percentage of spill increased from 1995 to 1998, the horizontal distribution of juvenile salmon shifted from being skewed toward the south end of the powerhouse to a somewhat more even distribution, even though more observations still occurred in the powerhouse areas of the forebay than in the spillway areas. The higher numbers of fish observations recorded in the powerhouse areas indicate that they were holding in those areas and so were recorded for more multiple observations than were fish observed in the spillway forebay that passed through the spillway quicker. Horizontal distribution is more indicative of where fish are holding and less indicative of where they passed. Records of individual fish from 1995 to 1998 show that fish were recorded in multiple areas indicating searching or milling behavior was taking place.

Table 3.5. Horizontal Distribution of Radio-Tagged Juvenile Salmon in John Day Forebay, as Indicated by Percent of Tagged Fish Observed in Each Area Monitored by Fixed Array of Antennas, 1995-1998 (navigation lock observations included in north spill)

Species	Sample Size	Percent of Fish Observed				% Spill Average
		South Power-house	North Power-house	South Spill	North Spill	
1995[a]						
CHIN 1	100	68.0	23.3	2.6	6.0	3.9
1996[b]						
CHIN 1	138	60.4	22.6	6.3	10.7	20.7
CHIN 0	75	57.6	24.4	7.1	10.7	18.4
1997[c]						
STH 1	122	57.2	21.6	6.3	14.9	33.0
CHIN 1	115	49.4	23.3	5.0	22.3	33.0
CHIN 0	95	36.1	26.2	10.4	27.3	19.9
1998[d]						
STH 1	119	33.6	26.9	12.0	27.5	43.3
CHIN 1	120	34.6	47.9	6.1	11.4	43.3
CHIN 0	119	38.7	28.6	8.2	24.5	53.2

(a) Sheer et al. 1997.
(b) Holmberg et al. 1997.
(c) Hensleigh et al. 1999.
(d) Liedtke et al. 1999.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

3.4 Tailrace Egress

The route of passage of juvenile salmon into the tailrace and subsequent egress and residence time in the near dam tailrace may have a significant impact for survival of these fish. Direct mortality may occur through extreme hydraulic and physical forces and indirect mortality may occur through increased exposure and vulnerability to predators. Spill patterns and volumes and powerhouse operations are very important determinants influencing where juvenile salmon exit the tailrace, how long they reside there, and in what condition they are delivered into the tail waters.

The first study to examine tailrace egress of juvenile salmon at John Day Dam was conducted in 1993 by Snelling and Schreck (1995). They released a total of 89 yearling chinook salmon in small groups on ten dates from April 21 – June 9, 1993. About one-half of the fish were released through the bypass outfall and the other half were released as a control or reference in the river at and just below the outfall exit. They found no major differences in residence time or route of passage down to an exit monitoring station 5.2 km below the dam (exit times ranged from 48 to 89 min). Only 2 of the 89 fish delayed. These held at a point 4.5 km down from the dam then continued downstream in a manner consistent with normal migration. River discharge ranged from 160 to 326 thousand cubic feet per second (kcfs) during releases. Spill occurred at 100 kcfs only during two of the release dates, May 12 and 14, and it appeared to have no real effect on residence times or routes taken.

In 1998, Liedtke et al. (1999) described the tailrace egress and behavior of radio-tagged yearling (n=147) and subyearling chinook salmon (n=152) and yearling steelhead (n=154) released through spill bays 2, 10, and 18 at John Day Dam. River conditions did not vary markedly during spring (May 5-29) or summer (June 15 – July 10). In spring, river discharge ranged from 291 to 361 kcfs and spill ranged from 141 to 152 kcfs during fish releases. Fish released from bay 10, in the middle of the spillway, had the lowest residence times and highest travel rates. Fish from bay 2 had residence times similar to fish released from spill bay 10 and fish released from bay 18 had the longest residence times and slowest travel rates (Table 3.4). In summer, the river discharge was lower than in spring ranging from 171.5 to 276 kcfs and spill discharge ranged from 45 to 64 kcfs. Similar results of tailrace residence time occurred for the subyearlings with tagged fish released from bay 18 again having the longest residence times (Table 3.4). Radio-tagged drogues released through the same spill bays had similar residence and travel rates as fish. About 10% of the subyearling chinook salmon appeared to be consumed by predator fish (16 of 152) – six from bay 2, six from bay 18, and four from bay 10.

Table 3.4. Mean Tailrace Residence Time (in minutes) of Radio-Tagged Juvenile Salmon Released through the Spillway into the John Day Dam Tailrace to the First Exit Point Transect, 0.7 km Downriver from the Dam, 1998 and 2000. For the overall summary, means without letters in common are significantly different by Duncan's Multiple Range Test ($P<0.05$).

Species	% Spill Average	Mean Tailrace Residence Time (in minutes)			
		Bay 2	Bay 10	Bay 18	Bypass
1998[(a)]					
STH 1	43	7.4 B	4.2 A	9.9 C	NA
CHIN 1	43	5.4 B	4.3 A	7.3 C	NA
CHIN 0	53	5.0 A	4.8 A	7.3 B	NA
2000[(b)]					
STH 1	30	10.6 A	9.2 A	NA	10.3 A
STH 1	53	7.9 AB	5.5 B	NA	10.4 A
CHIN 1	30	7.2 A	13.3 A	NA	10.2 A
CHIN 1	53	8.7 B	6.2 B	NA	26.2 A
CHIN 0	30	7.9 B	10.2 B	NA	18.1 A
CHIN 0	53	6.4 B	6.8 B	7.4 B	97.7 A

(a) Liedtke et al. 1999.
(b) Duran et al. 2000a and 2000b.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

In 2000, Duran et al. (2000a and 2000b Interim Reports) conducted studies similar to those in 1998 to again describe the tailrace egress and behavior of radio-tagged yearling (n=144) and subyearling chinook salmon (n=150) and yearling steelhead (n=138) released through spill bays 2, 10, 18, and the bypass outfall (in summer spill bay 14 was used instead of spill bay 18). In 2000 tests were conducted at John Day Dam to determine spill and fish passage efficiency during 12-h and 24-h treatments. The 12-h treatment consisted of 0% day spill and 60% night spill and the 24-h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 53%). Spill treatments were alternated every three days during four six-day blocks during spring. For the tailrace tests the 0% spill condition was not tested. During 30% spill tests the mean residence times were similar for yearling chinook salmon from all release sites averaging about 10 min (Table 3.4). During the 60% spill tests, however, the residence time of yearling chinook salmon released from the bypass averaged about three times longer than those for the fish released from the spill bays. For steelhead the fish released from bay 18 had consistently longer residence times than did those from all other release sites for both 30% and 60% test conditions. Sub-yearling chinook salmon released from the bypass had the highest tailrace residence times during both 30% and 60% spill conditions. Generally, the mean residence times of all subyearlings released from the spill bays were not significantly different between the 30% and 60% tests. Fish released from the bypass during 30% spill had significantly lower mean residence times than bypass fish during 60% spill.

Usually, fish passing through the north (bay 2) and middle (bay 10) spill bays had significantly shorter tailrace residence times than did fish passing through the south spill bays (bay 18 – note that in 2000, spillbay 18 was closed for most releases). In 2000, fish passing through the bypass usually had similar residence times to those passing bays 2 and 10 for 30% spill, but substantially longer residence times during 53% spill, especially for chinook salmon yearlings and subyearlings. It should be noted that during the 2000 egress tests, the release hoses were fixed in the three test spill bays, so when spill discharges were varied between 30 and 53%, the radio tagged salmonids actually entered the tailrace into different hydraulic environments. This should be taken into consideration when interpreting the data. Regardless, the considerable difference in residence times at high spill level may demonstrate the need for additional research to determine if there is a relationship between tailrace residence time and route-specific survival.

3.5 Predation

Losses of juvenile salmon to predators can be significant, and in one John Day Reservoir study estimated losses to predation were 2.7 million per year for 1983-1986, with monthly predation mortality ranging from 7% in June to 61% in August (Rieman et al. 1991). The tailrace boat restricted zone for boats at McNary Dam was by far the most concentrated area of predation by the northern pikeminnow (*Ptychocheilus oregonensis*) and this small area accounted for over 20% of all those losses.

Concentrations of northern pikeminnow have been documented to be relatively high in the John Day forebay and tailrace, especially the boat restricted zones (Rieman et al. 1991; Poe et al. 1991; Vigg et al. 1991; and Ward et al. 1995). Consumption of juvenile salmon by northern pikeminnow in these areas has also been documented to be quite high and in 1990 ranged from 2.2 smolts/predator/day (indexed consumption) in the John Day forebay to about 4.0 smolts/predator/day (indexed consumption) in the John Day tailrace (Petersen et al. 1991). Those rates are strongly affected by increasing water temperatures and smaller smolt size in summer.

The behavior and distribution of 71 radio-tagged northern pikeminnow were monitored from May through September 1993 in the tailrace of John Day Dam (Hansel et al. 1995; Shively et al. 1995). The objective of the study was to aid in establishing biological criteria for optimum location of juvenile bypass outfalls and to examine modes of project operation that may reduce predation in tailrace areas of dams. Radio-tagged fish were monitored with fixed receiver stations (arrays of antennas connected to data loggers) and frequent mobile tracking. Northern pikeminnows used areas away from the spillway stilling basin during periods of high spill (mostly in May) but switched to areas in the spill basin and at the powerhouse tailrace in July and August when subyearling chinook salmon were abundant and dam discharges were reduced. During the study the river discharge peaked at 401 kcfs on May 17 with maximum spill of 164 kcfs on May 23 and most spill occurred at night. About twice as many predators were contacted at night as during the day. This was thought to be a function of greater juvenile fish passage at night since predators would be more active then. The area of the outfall bypass was also closely monitored for aggregations of predators, but of all position fixes of predators in the tailrace through the season fewer than 1% occurred within a radius of 200 m downriver of the bypass outfall.

In conclusion, the potential for indirect mortality of juvenile salmon due to predation by the northern pikeminnow in both the forebay and tailrace of JDA appears to be high, especially during summer. Passage delay leading to increased residence times in the forebay will concentrate smolts, thus attracting predators. Spill patterns and operational conditions that cause smolts to have longer tailrace residence times will also concentrate smolts which may attract predators. Route-specific survival studies and predator monitoring studies are needed to better understand these risks.

4.0 Fish Passage

4.1 Radio Telemetry Results

4.1.1 Estimated Route of Passage

Route of passage for radio-tagged juvenile s almon is a key measure for determining such metrics as fish passage efficiency (FPE), which is dependent on getting accurate passage location data. In the earlier radio telemetry studies at John Day (1983-1984 and 1995-1998), routes of passage were estimated using only aerial antennas and standard receivers to locate the areas where the radio-tagged fish were last contacted. This was generally good enough for major passage routes such as the powerhouse or spillway. This method is not accurate enough, however, to distinguish more specific routes of passage such as through specific spill bays, turbine units, or bypass systems. To obtain more accurate passage data from radio-tagged fish, arrays of underwater antennas connected to receivers and Digital Spectrum Processors (DSPs) are needed. (DSPs can simultaneously monitor all antennas and pulse-coded transmitters so the probability of missing a tagged fish is minimized.) These techniques were used extensively at John Day Dam in 1999 and 2000 (Hansel et al. 2000a & b; Beeman et al. 2000).

In 1983 and 1984, the NMFS conducted a radio telemetry study to examine passage behavior during spill at John Day Dam (Giorgi et al. 1985). Passage routes were determined by noting location of last contact as monitored by aerial antennas and standard receivers. In 1983, 90% of the yearling chinook salmon (10 of 11) passed through the spillway when spill volume was 50% of river flow and only 40% of the yearling steelhead (2 of 5) passed the spillway when spill was 41% of river flow. In 1984, during spill of 42%, 74% of the radio-tagged yearling chinook salmon passed through the spillway.

In 1995 the USGS (Sheer et al. 1997) estimated that radio-tagged yearling chinook salmon passed the John Day Dam through the various routes in the following proportions: juvenile bypass system 4.3%, south powerhouse 43.4%, north powerhouse 27.5%, south spillway 14.4%, and north spillway 10.1% (Table 4.1 and Figure 4.1). The juvenile bypass system passage route was only monitored by a standard receiver and not a DSP linked to a receiver system, so the 4.3% passage data for the bypass route is probably a significant underestimate of the number of fish passing through the screened bypass system, because the scan rate would have been too slow to detect fish moving through at a rapid rate. Powerhouse discharge during times of fish passage ranged from 210 to 296 kcfs and spillway discharge ranged from 8 to 14 kcfs.

From 1996 to 1998 (Holmberg et al. 1997; Hensleigh et al. 1999; Liedtke et al. 1999), the USGS radio telemetry studies continued with the same basic study design and equipment to estimate route of passage. Table 4.1 below shows the estimated routes of passage (as % by route) that radio-tagged juvenile salmon used to pass the dam from 1995 to 1998. Percent passage of subyearling chinook salmon through the southern and northern portions of the spillway combined increased in 1998 compared to 1996 and 1997 (Table 4.1 and Figure 4.2). In 1997 and 1998, steelhead passage was highest through the southern and lowest through the northern portion of the powerhouse (Table 4.1 and Figure 4.3). The percentage of steelhead passage through the northern portion of the spillway decreased slightly from 1997 to 1998.

Table 4.1. General Routes of Passage (as % by location) for Radio-Tagged Juvenile Salmon at John Day Dam 1995 – 1998

Species	Sample Size	Percent of Fish Passed				% Spill, Average	Spill, Range (kcfs)	River Discharge Range (kcfs)
		South Power-house	North Power-house	South Spill	North Spill			
1995[a]								
CHIN 1	100	43.4	27.5	14.4	10.1	3.9	8-13	250-296
1996[b]								
CHIN 1	138	40.2	17.9	22.3	20.8	20.7	47-125	298-450
CHIN 0	75	33.3	27.0	18.7	20.8	18.4	55-56	225-359
1997[c]								
STH 1	122	31.4	14.0	23.1	31.5	33.0	92-215	397-540
CHIN 1	115	18.1	17.7	28.4	35.8	33.0	92-215	397-540
CHIN 0	95	26.8	23.6	32.1	17.5	19.9	58-62	291-308
1998[d]								
STH 1	119	30.3	17.4	26.7	25.6	43.3	150-223	292-468
CHIN 1	120	11.6	13.7	31.6	43.1	43.3	150-223	292-468
CHIN 0	119	10.3	13.2	19.1	57.4	53.2	116-141	208-302

(a) Sheer et al. 1997.
(b) Holmberg et al. 1997.
(c) Hensleigh et al. 1999.
(d) Liedtke et al. 1999.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

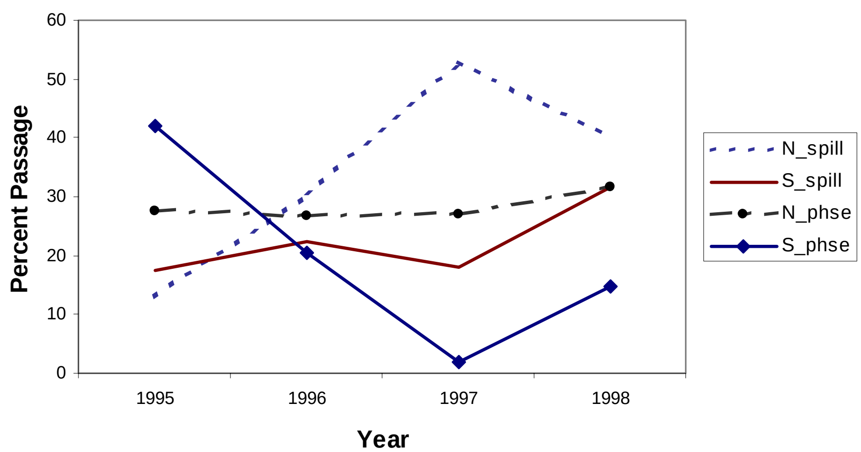

Figure 4.1. Percent Passage by Major Route for Yearling Chinook Salmon through John Day Dam 1995-1998

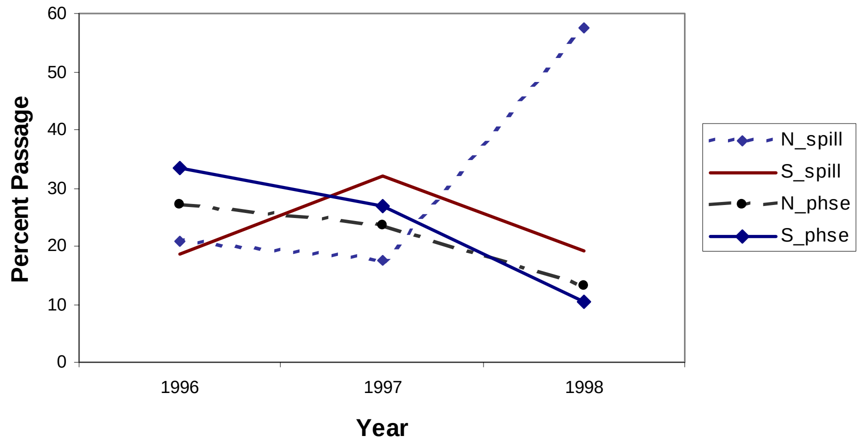

Figure 4.2. Percent Passage by Major Route for Subyearling Chinook Salmon through John Day Dam 1996-1998

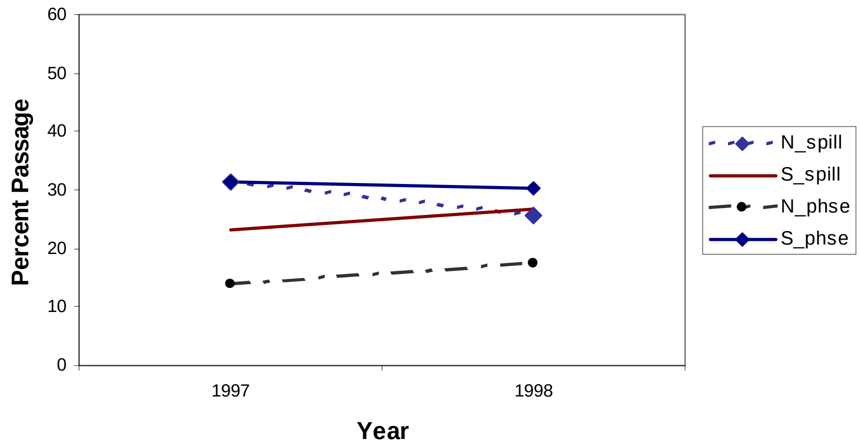

Figure 4.3. Percent Passage by Major Route for Steelhead through John Day Dam 1995-1998

In 1999 and 2000 (Hansel et al. 2000a & b; Beeman et al. 2000) the USGS conducted radio telemetry studies at John Day Dam during 12-h and 24-h spill tests to determine the proportions of radio-tagged juvenile salmon passing through the spillway and through the powerhouse, guided (i.e., through the juvenile bypass system) and unguided (i.e., through the turbines). Table 4.2 below gives the general route of passage data for these studies. Daytime spill was 0% during the 12-h treatment and 30% during the 24-h treatment. Nighttime spill was 45% in 1999 and 53% in 2000.

Estimates of passage-route efficiency are accurate if detection efficiency is the same at each passage route or if it can be estimated and detections adjusted accordingly. It is not clear from the reports if either of those conditions were demonstrated. Often it is assumed that detection probability is equivalent across passage routes; however, depth of migration or fish speed may vary by route potentially affecting detection probability. Depending on the system design this may not be problematic.

Table 4.2. General Routes of Passage of Radio-Tagged Juvenile Salmon (% by route) at John Day Dam during 12-h and 24-h, Day versus Night Spill Treatments, 1999 and 2000

Species and Location	Percent of Fish Passed	
	12-h Spill	24-h Spill
1999[a]	00/45 Day/Night	30/45 Day/Night
STH 1 (n=275)		
Powerhouse	55	47
Spillway	45	53
CHIN 1 (n=293)		
Powerhouse	47	34
Spillway	53	66
2000[b]	00/53 Day/Night	30/53 Day/Night
STH 1 (n=487)		
Powerhouse	31	27
Spillway	69	73
CHIN 1 (n=484)		
Powerhouse	34	17
Spillway	66	83

(a) Hansel et al. 2000a and 2000b.
(b) Beeman et al. 2000.

CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

4.1.2 Diel Passage

Diel passage data from a variety of sources indicates that there is a strong trend for fish passing John Day Dam to pass the project at night rather than daytime. The radio telemetry studies conducted in 1999 and 2000 were the only radio telemetry studies that collected enough data to discern diel patterns of passage. This was because there were high enough numbers of tagged fish entering the forebay throughout the 24-h blocks studied to depict diel passage patterns. Because a majority of juveniles passed the dam at night (especially steelhead where often over 90% passed at night regardless of treatment), it is important to examine and compare day and night differences. These are seen in Table 4.3 on the next page.

An easier way to see differences in species-specific passage, day versus night, is in Figure 4.4 and Figure 4.5. They show that the addition of day spill certainly increases the proportion of juvenile salmonids passing the spillway during the day (especially yearling chinook salmon in 2000). Unfortunately, nearly the same proportion of fish that passed the spillway during the day would have been guided to the juvenile bypass system if they passed at night resulting in no significant change in FPE. There may still be a benefit to day spill, though, because of the considerable reduction in passage delay of juvenile chinook salmon arriving during the day.

Table 4.3. Diel Passage of Radio-Tagged Juvenile Salmon (% by route) at John Day Dam 1999 and 2000

Species and Location	Percent of Fish Passed		
	0% Day Spill	30% Day Spill	45% Spill Pooled Night
1999[(a)]			
STH 1	(n=15)	(n=24)	(n=256)
Turbine	13.4	21.8	6.2
JBS	73.4	30.4	42.6
Spillway	13.3	47.8	51.2
CHIN 1	(n=29)	(n=65)	(n=220)
Turbine	17.2	9.2	16.4
JBS	75.9	16.9	21.8
Spillway	6.9	73.9	61.8
2000[(b)]	0% Day Spill	30% Day Spill	53% Spill Pooled Night
STH 1	(n=10)	(n=19)	(n=415)
Turbine	50	5.3	8.7
JBS	50	26.3	18.3
Spillway	0	68.4	73.0
CHIN 1	(N=30)	(N=106)	(N=322)
Turbine	40	4.7	12.4
JBS	60	2.8	10.6
Spillway	0	92.5	77.0

(a) Hansel et al. 2000a and 2000b.
(b) Beeman et al. 2000.
JBS = juvenile bypass system.
CHIN1 = yearling chinook salmon.
CHIN0 = subyearling chinook salmon.
STH1 = yearling steelhead.

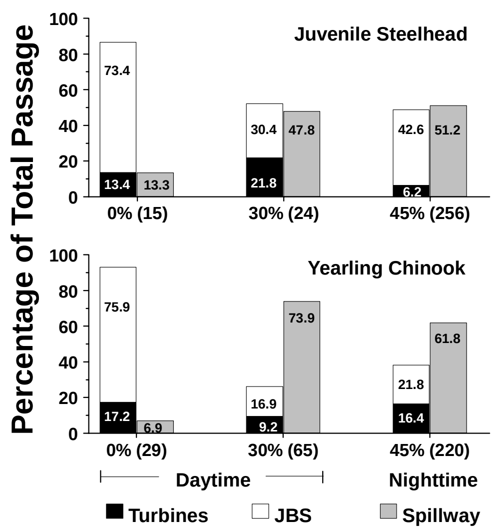

Figure 4.4. Passage Routes (by %) for Radio-Tagged Juvenile Steelhead and Yearling Chinook Salmon at John Day Dam at “0%” and 30% Daytime Spill and 45% Nighttime Spill, Spring 1999. Specific percentages for each route are shown on bars. During 0% spill there were small amounts of spill through which some fish passed. JBS = juvenile fish bypass system. Sample sizes are in parentheses. From Hansel et al. (2000a).

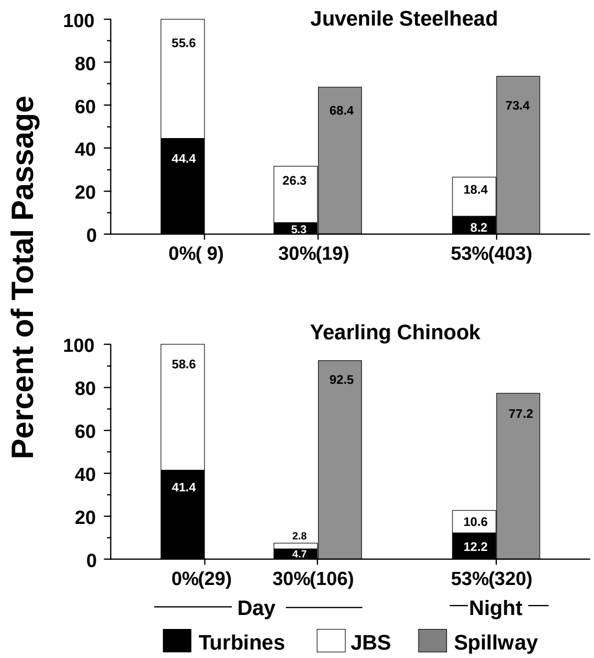

Figure 4.5. Passage Routes (by %) for Radio-Tagged Juvenile Steelhead and Yearling Chinook Salmon at John Day Dam during "0%" and 30% Day Spill and 53% Night Spill, 02 May through 26 May 2000. Specific percentages for each route are shown on bars. JBS = juvenile bypass system. Sample sizes are in parentheses. From Beeman et al. (2000).

4.1.3 Spill Passage Efficiency, Spill Passage Effectiveness, and Fish Passage Efficiency

In the earlier radio telemetry studies, 1984 and 1995-1998, limitations of low sample sizes and use of only aerial antennas (no underwater antennas or DSPs) prohibited the ability to statistically determine differences in SPE. However, it is still valuable to use estimates of SPEs from those studies to complement hydroacoustic estimates and examine long-term trends. The 1999 and 2000 radio telemetry studies significantly improved the accuracy and precision of the passage metrics, so we will describe and discuss those studies in some detail. Spill efficiency and effectiveness and fish passage efficiency are summarized in Table S.1.

In the spring of 1999 (Hansel et al. 2000a), tests were conducted to determine the proportion of radio-tagged juvenile steelhead and yearling chinook salmon passing through the spillway and powerhouse (guided through the juvenile bypass and unguided through the turbines) at John Day Dam during 12-h and 24-h spill treatments. Radio-tagged yearling chinook salmon (n=469) and yearling steelhead (n=479) were released 23 km above the dam. Fixed station monitoring stations with arrays of aerial antennas were mounted on the dam and underwater antennas were fixed to monitor turbine units, tainter gates, and the juvenile bypass system. The 12-h treatment consisted of 0% day spill and 60% night spill and the 24-h treatment consisted of 30% day spill and 60% night spill. (Actual night spill averaged 45%; also a small amount of spill occurred during 0% spill periods.) Spill treatments were alternated every three days during three six-day blocks during spring. (The fourth intended block was not met).

In 1999, steelhead FPE was 94% during the 12-h treatment and 90% during the 24-h treatment. Yearling chinook salmon FPE was 82% and 87% during 12-h and 24-h treatments respectively. None of the FPEs were significantly ($P \leq 0.05$) different. Steelhead SPE did not differ significantly between treatments, but yearling chinook salmon SPE was significantly greater during the 24-h treatment than the 12-h treatment. Steelhead SPE estimates were 45% and 53% during the 12-h and 24-h treatments, respectively, and yearling chinook salmon SPEs were 53% and 66%.

In the summer of 1999 (Hansel et al. 2000b) similar tests were conducted to determine the proportion of radio-tagged juvenile subyearling chinook salmon passing through the spillway and powerhouse at John Day Dam during 12-h and 24-h spill treatments. Radio-tagged subyearling chinook salmon (n=298) were released 23 km above the dam. Fixed station monitoring stations with arrays of aerial antennas were mounted on the dam. As digital transmitters were not available, FPE could not be determined. In 1999 tests were conducted at John Day to determine spill and fish passage efficiency during 12-h and 24-h treatments. The 12-h treatment was to consist of 0% day spill and 60% night spill and the 24-h treatment was to consist of 30% day spill and 60% night spill. None of the intended spill levels were met as planned, so only general SPE was acquired. Daytime spill at volumes occurring in 1999 appeared to increase the over-all 24-h spill passage of subyearlings. During blocks 1 and 2, 44% and 58% of the fish passed through the spillway during daytime no spill and daytime spill, respectively, while the remaining 56% and 42% of the fish passed through the powerhouse (guided or unguided). During block 3, 50% and 78% of the fish passed through the spillway during daytime no spill and daytime spill, respectively, while 50% and 22% of the fish passed through the powerhouse. Most fish (70%) arriving during periods of spill passed during the same diel conditions that were present when they arrived, but 55% of the fish arriving during days without spill delayed passage until night.

In 2000 (Beeman et al. 2000 – Preliminary) tests were again conducted by the USGS to determine the proportion of radio-tagged juvenile steelhead and yearling chinook salmon passing through the spillway and powerhouse (guided and unguided) at John Day Dam during 12-h and 24-h spill treatments. Radio-tagged yearling chinook salmon (n=484) and yearling steelhead (n=487) were released 23 km above the dam. Fixed station monitoring stations with arrays of aerial antennas were mounted on the dam and underwater antennas were fixed to monitor turbine units, tainter gates, and the juvenile bypass system. The 12-h treatment consisted of 0% day spill and 60% night spill and the 24-h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 53%). Spill treatments were alternated every three days during four six-day blocks during spring. Results of the study indicated that steelhead FPE was 93% during the 12-h treatment and 88% during the 24-h treatment. Yearling chinook salmon FPE was 84% and 90% during 12-h and 24-h treatments, respectively. None of the FPEs were significantly different. Steelhead SPE did not differ significantly between treatments but yearling chinook salmon SPE was significantly greater during the 24-h treatment than the 12-h treatment. Steelhead SPE estimates were 69% and 73% during the 12-h and 24-h treatments, respectively, and yearling chinook salmon SPEs were 66% and 83%. Spill effectiveness was greater during day spill than night spill and all values were greater than 1:1. Steelhead during day spill was 2.3:1 and yearling chinook salmon was 3.0:1.

4.2 Hydroacoustics Results

4.2.1 Project-Wide Estimates

The emphasis of the hydroacoustic monitoring effort at John Day Dam from 1980 to 1989 was to provide information on daily and seasonal run timing of juvenile salmon to synchronize spill with prime nighttime passage times (2000-0600 h) (Magne, Nagy, and Maslen 1983; Magne, Nagy, and Maslen 1987; Magne, Bryson, and Nagy 1987; Kuehl 1987; Ouelette 1988; McFadden and Hedgepeth 1990; Johnson and Wright 1987). Generally, water was spilled if the previous day's 24-h total passage estimate exceeded 30,000 fish. The objectives of the hydroacoustic monitoring effort that were typically addressed each year were 1) to estimate spill passage efficiency and effectiveness, 2) to describe horizontal distributions of fish passage at the powerhouse and spillway, and 3) to describe the vertical distribution of fish passage at the powerhouse. From 1998 to 2000, hydroacoustics were used to evaluate spill passage efficiency at various levels of daytime and nighttime spill percentages. Results from the hydroacoustic studies conducted between 1980 and 2000 are summarized in Table S.2. Detailed results are compiled in Tables 4.4 and 4.5.

The construction of a juvenile bypass system with submerged traveling screens (STS) was initiated at John Day Dam in 1984 with the first nine units screened by the end of July 1985. Hydroacoustics were first used to evaluate the fish guidance efficiency of the intake screens in 1996 (BioSonics, Inc. 1996; Ploskey and Carlson 1999). Following installation of the intake screens, hydroacoustics continued to be used only as a tool to evaluate spill performance and powerhouse passage. To date, no additional hydroacoustic estimates of fish guidance efficiency have been reported.

Estimates of project FPE are not presented in the hydroacoustic reports related to John Day Dam from 1980 to 2000. Prior to installation of the intake screens in 1984 and 1985, spill passage efficiency is analogous to FPE. Following screen installation, fish guidance efficiency is used to partition powerhouse fish passage into guided and unguided percentages; coupling these estimates with spill passage efficiency would then yield FPE. Accordingly, hydroacoustic results presented herein relate to trends in spill passage efficiency, spill effectiveness, horizontal and vertical distributions of fish passage, and diel and seasonal run timing.

4.2.2 Differences in Deployments, Acquisition Settings, and Processing

Sample locations, deployments, and system configurations of the hydroacoustic monitoring efforts at John Day Dam have varied substantially over the past two decades. Hydroacoustic monitoring efforts can be partitioned into two sampling periods, 1980-1989 and 1997-2000.

From 1980 to 1989 fish passage at the powerhouse and spillway was monitored using 15° single-beam transducers. In 1980 and 1981 powerhouse passage was monitored at two (1980) or three (1981) turbines and one (1980) or two (1981) spill bays. The relatively small deployment was due in part to the researchers investigating hydroacoustics as a tool to monitor juvenile fish passage. The number of powerhouse and spillway locations increased from 1983 to 1989. During this period, passage at six or seven turbine units and six spill bays was monitored. Transducers were distributed across the

Table 4.4. Metrics and Sampling Characteristics of Fixed Aspect Hydroacoustic Studies Conducted in Summer from 1982 through 1989

Sampling Metric	Study Year								
	1980[a]	1981[a]	1983[b]	1984[c]	1985[c]	1986[d]	1987[e]	1988[f]	1989[g]
Performance/Passage Metrics									
Project FPE	NA	NA	NA	NA	NA	NA	NA	NA	NA
Spill efficiency (spring/summer)	NA	NA	0.39 spr. 0.40 sum.	0.38 sum.	0.21 spr.	0.32 sum.	0.23 sum.	0.19 sum.	0.28 sum.
Turbine fraction	NA	NA	0.63	0.58	0.67	NA	0.89	0.90	0.86
Spill effectiveness	NA	NA	0.79 spr. 1.04 sum.	0.76 sum.	0.75 spr.	1.04 sum.	1.3 sum.	1.1 sum.	1.4 sum.
Sampling dates	4/22-6/11	4/20-8/13	4/23-8/26	6/5-8/26	4/21-7/28	7/17-8/14	6/7-8/15	5/13-8/15	6/11-8/23
Sampling duration	0000-2300	1700-0500	2000-0600	2100-0500	2100-0500	2000-0500	2100-0500	2100-0500	2000-0600
Mean project discharge (ft^3/s)	259,188	263,447	257,501	233,233	186,423	150,238	118,793	142,086	119,249
Spill discharge fraction	0.08	0.19	0.33	0.30	0.38	0.30	0.18	0.18	0.21
Turbines sampled	2 of 16	3 of 16	7 of 16	6 of 16	6 of 16	7 of 16	6 of 16	6 of 16	6 of 16
Spill bays sampled	1 of 20	2 of 20	6 of 20	6 of 20	6 of 20	6 of 20	5 of 20	4 of 20	6 of 20
Powerhouse Metrics									
Turbine transducers	15º, forebay	15º, forebay	15º, forebay	15º, forebay	15º, forebay	15º, forebay	15º, forebay	15º, forebay	15º, forebay
Samples/hour	4 or 3	4 or 3	3	3	3	2	4	3	2
Sample duration (min)	5 or 4	5 or 4	~2	2.5	2.5	5	3.6	5	7
Minutes/hour	20	20	6	7.5	7.5	10	14.4	15	14
Pings/second	12	12	12	4	4	5	5	5	5
Echoes/fish	5+	5+	5+	5+	5+	4+	4+	4+	4+
Horizontal distributions	Yes	Yes	Yes	NA	NA	Yes	Yes	Yes	Yes
Vertical distributions	Yes	Yes	Yes	NA	NA	Yes	Yes	Yes	Yes

Table 4.4. (contd)

Sampling Metric	Study Year								
	1980[a]	1981[a]	1983[b]	1984[c]	1985[c]	1986[d]	1987[e]	1988[f]	1989[g]
Temporal distributions	Yes	Yes	Yes	NA	NA	Yes	Yes	Yes	Yes
Spillway metrics									
Spill transducers	15°	15°	15°	15°	15°	15°	15°	15°	15°
Samples/hour	4 or 3	4 or 3	3	3	3	2	1 or 2	1, 2, or 3	1 or 2
Sample duration (min)	5 or 4	5 or 4	2.5	2.5	2.5	3.2	45 or 22.5	45 or 15	45 or 22.5
Minutes/hour	20	20	7.5	7.5	7.5	6.4	45 or 22.5	45 or 15	45 or 22.5
Pings/second	12	12	12	12	12	10	10	10	10
Echoes/fish	5+	5+	5+	3+	3+	4+	2+	4+	4+
Horizontal distributions	NA	NA	Yes	NA	NA	Yes	NA	NA	Yes
Vertical distributions	NA	NA	NA	NA	NA	NA	NA	NA	Yes
Temporal distributions	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes
Detection threshold (dB)	-50	-50	-47 and -50	-50	-50	-56	-55 spring, -59 summer	-56	-56
Detection modeling	?	?	?	?	?	Yes	Yes	Yes	Yes
Detectability corrected	No	No	No	No	No	No	No	No	No
Target strength used to correct detectability?	No	No	No	No	No	No	No	No	No
Run timing		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(a) Magne, Nagy, and Maslen 1983.
(b) Magne, Nagy, and Maslen 1987.
(c) Magne, Bryson, and Nagy 1987.
(d) Kuehl 1987.
(e) Johnson and Wright 1987.
(f) Ouellette 1988.
(g) McFadden and Hedgepeth 1990.
NA = data not available.

Table 4.5. Metrics and Sampling Characteristics of Fixed Aspect Hydroacoustic Studies Conducted in Summer from 1996 through 2000

Sampling Metric	Study Year				
	1996[a]	1997[b]	1998[c]	1999[d]	2000[e]
Performance/Passage Metrics					
Project FPE	NA	NA	NA	NA	NA
Spill efficiency (spring/summer)	NA	0.53 spr./0.85 sum.	0.63 spr./0.49 sum.	0.82 spr./0.93 sum.	0.79 sum.
Turbine fraction (spring/summer)	NA	0.49 spr./0.19 sum.	0.34	0.18 spr./0.07 sum.	0.21
Spill effectiveness (spring/summer)	NA	2.32 spr./3.92 sum.	2.92 spr./1.89 sum.	2.74 spr./3.76 sum.	2.79 sum.
Sampling dates	5/8-7/23	5/5-7/24	4/19-7/18	5/1-7/8	6/6-7/9
Sampling duration	0000-2300	0000-2300	0000-2300	0000-2300	0000-2300
Mean project discharge (ft^3/s)	335,947	486,676	283,387	313,225	195,324
Spill discharge fraction	0.21	0.35	0.32	0.27	0.36
Turbines sampled	1 of 16	8 of 16	8 of 16	15 of 16	16 of 16
Spill bays sampled	0 of 20	10 of 20	11 of 20	11 of 20	11 of 20
Powerhouse Metrics					
Turbine transducers	6º, in	6º, in	6º, in	6º, in	6º, in
Samples/hour				6	4
Sample duration (min)		5	2.5	2	2.5
Minutes/hour		15+		12	10
Pings/second	10	10	20	20	12
Echoes/fish	4+	4+	4+	4+	4+
Horizontal distributions	NA	Yes	Yes	Yes	Yes
Vertical distributions	NA	Yes	Yes	Yes	Yes
Temporal distributions	NA	Yes	Yes	Yes	Yes
Spillway Metrics					
Spill transducers	NA	12º/15º	15º	10º	12º
Samples/hour	NA	3	?	5	4
Sample duration (min)	NA	5	2.5	2	2.5
Minutes/hour	NA	15	?	10	10

Table 4.5. (contd)

Sampling Metric	Study Year				
	1996[a]	1997[b]	1998[c]	1999[d]	2000[e]
Echoes/fish	NA	4+	4+	4+	4+
Horizontal distributions	NA	Yes	Yes	Yes	Yes
Vertical distributions	NA	Yes	Yes	Yes	Yes
Temporal distributions	NA	Yes	Yes	Yes	Yes
Detection threshold (dB)	-62	-50 weir-58 no weir	-56	-59	-56
Detection modeling	?	Yes	Yes	Yes	Yes
Detectability corrected?	No	No	No	No	Yes
Target strength used to correct detectability?	No	No	No	No	Yes
Run timing	Yes	Yes	Yes	Yes	Yes

(a) BioSonics 1996.
(b) BioSonics 1999a.
(c) BioSonics 1999b.
(d) Johnston, Nealson, and Horchik 2000.
(e) Moursund et al. 2001.

powerhouse, and were typically deployed at spill bays 15 through 20. Deployment at spill bays 15 through 20 was due to spill discharge occurring predominately through these bays. In 1997 and 1998 passage was monitored through eight turbines and ten (1997) and eleven (1998) spill bays. In 1999 and 2000, the hydroacoustic effort increased to sample passage at 15 turbines in 1999 and 16 turbines in 2000.

Another difference in hydroacoustic deployment between the two periods is the placement and type of transducers used to monitor turbine passage. From 1980 to 1989, 15° transducers sampled fish passage upstream of the turbine trash racks and from 1996 and 2000, 6° transducers were deployed in-turbine. With the higher in-turbine water velocities, pulse repetition rates increased to 10-20 pings/sec compared to 5 pings/sec for deployments upstream of the trash racks.

In addition to changes in transducer types and mounting locations, substantial strides have recently been taken toward integrating effective beam widths into the algorithms used to estimate fish passage. Ploskey et al. (2000) used data collected at The Dalles Dam in 1999 to assess the acoustic screen model and reiterated the importance of addressing assumptions of the model when estimating fish passage via hydroacoustic techniques. Some of the critical assumptions that should be addressed by hydroacoustic evaluations include truncation of targets by improper threshold, detectability by range, effective beam angle, target strength of population, and horizontal distribution within an orifice. Not until 1999 and 2000 were these assumptions addressed thoroughly by researchers at John Day Dam. Furthermore, prior to 2000, the effective beam widths of transducers were modeled and reported, but not incorporated correctly into the algorithms for estimating fish passage. Detectability models, which typically incorporate ping rate, fish trajectory through the beam, fish velocity, and range, have been used to demonstrate that within the sample range of interest the effective beam width approaches the nominal beam width. The effective beam width generally increases with range. However, prior to 2000, when calculating passage, the effective beam width was held constant over the entire sample range. In 2000, the effective beam widths used in estimating passage were range specific allowing for more precise passage estimates.

4.2.3 Horizontal Distribution of Fish Passage among Turbines and Spillways

The horizontal distribution of fish passage through the powerhouse and spillway may be influenced by project operations as fish passage generally follows the pattern of discharge. In 1988, fish passage was highest through the southernmost turbines (Turbines 1, 3, and 5); however, these three turbines also had the most discharge (Oulette 1988). Fish passage through the powerhouse was reported to be higher through the southern units for studies conducted in 1998, 1999, and 2000 (BioSonics 1999b; Johnston, Nealson, and Horchik 2000; Moursund et al. 2001).

In 1999 and 2000, passage was slightly higher at the south and north ends of the spillway. In 1999, passage and discharge was highest through spill bays toward the Washington shore (Johnston, Nealson, and Horchik 2000), demonstrating the possible influence of project operations on fish passage distribution.

4.2.4 Diel Distribution of Fish Passage among Turbines and Spillways

Data collected during the nighttime period from 1980 to 1989 indicated that powerhouse fish passage increased at dusk, peaking from 2100 to 2300 h, passage rates then leveled off until decreasing sharply from 0500 to 0600 h. A similar trend in passage timing was observed in 24-h monitoring conducted in 1999 (Figure 4.6)

Spillway passage was highest from approximately 0800 h to 1100 h for days with 30% daytime spill during both spring and summer periods in 1999 (Figure 4.7 and Figure 4.8). In Spring 1999, spillway passage efficiency was 68% for days with “0%” daytime spill and 82% for days with 30% daytime spill. (Spill was actually not 0%; some spill did occur because one spill gate was opened to attract adult fish to the fish ladder below.) Spillway passage efficiency was 63% for days with “0%” daytime spill and 93% for days with 30% daytime spill in summer 1999. The trend in the diel distribution of spillway passage observed in summer 2000 differed from that observed in 1999 with an increase in passage occurring at approximately 1900 hrs (Figure 4.9).

A difference in the timing of daily peak spillway passage for days with 30% spill was apparent between data collected in 1999 and 2000. In 1999, a strong mode in passage occurred from 0700-1300 h and passage rates remained low throughout the remainder of the 24-h period (Johnston, Nealson, and Horchik 2000) (Figure 4.10). In 2000, passage was lowest from 1100-1300 h and then increased steadily and peaked at 1900 h. Nighttime passage rates remained relatively high until decreasing around 0800-0900h (Moursund et al. 2001).

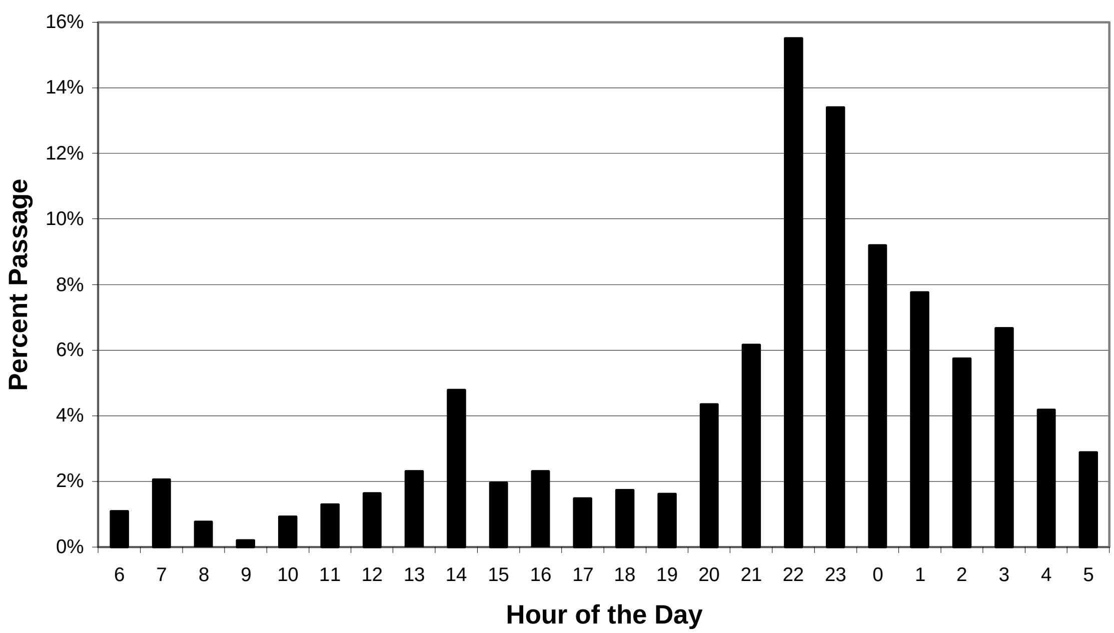

Figure 4.6. Diel Distribution of Fish Passage through the John Day Dam Powerhouse in Summer 1999. (adapted from Johnston, Nealson, and Horchik 2000)

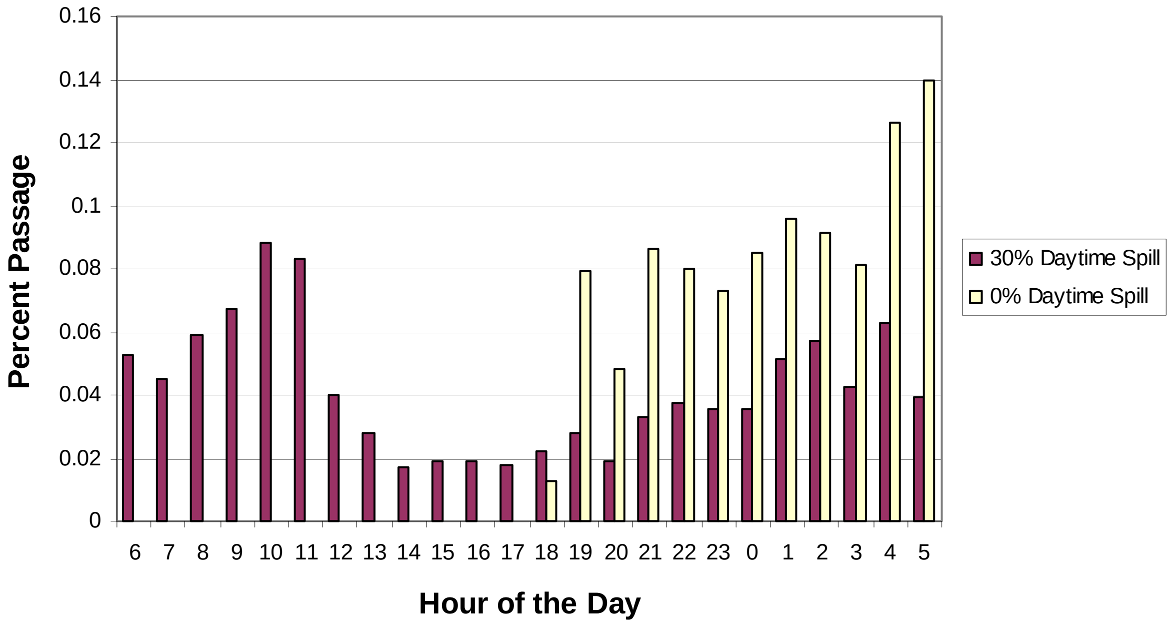

Figure 4.7. Diel Distribution of Spillway Passage at John Day Dam in Spring 1999

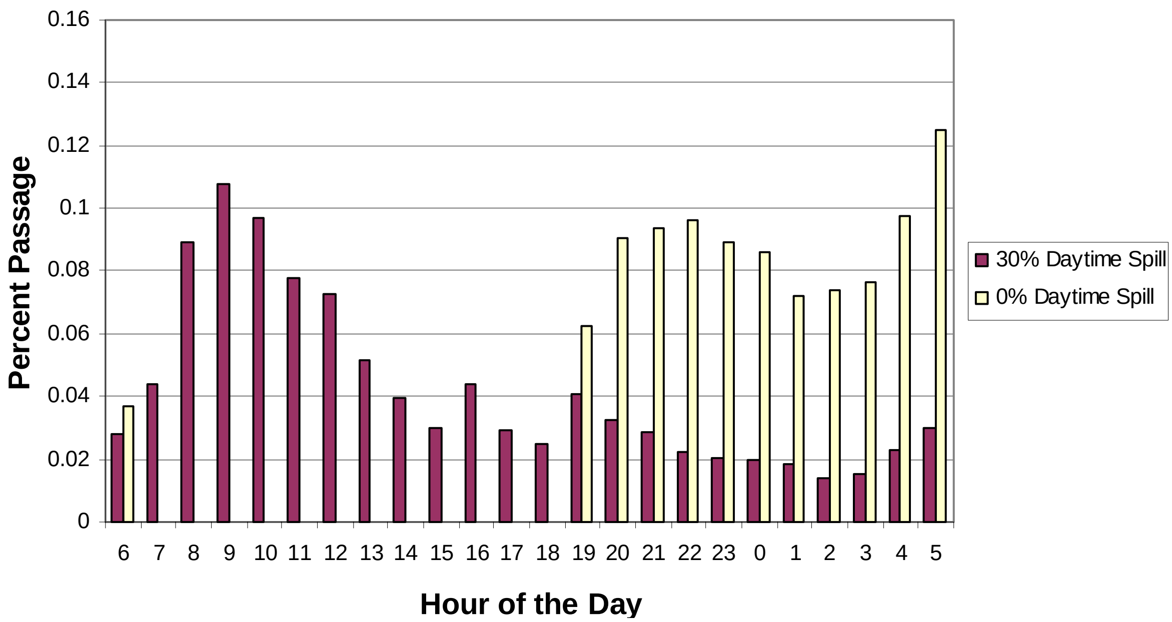

Figure 4.8. Diel Distribution of Spillway Passage at John Day Dam in Summer 1999

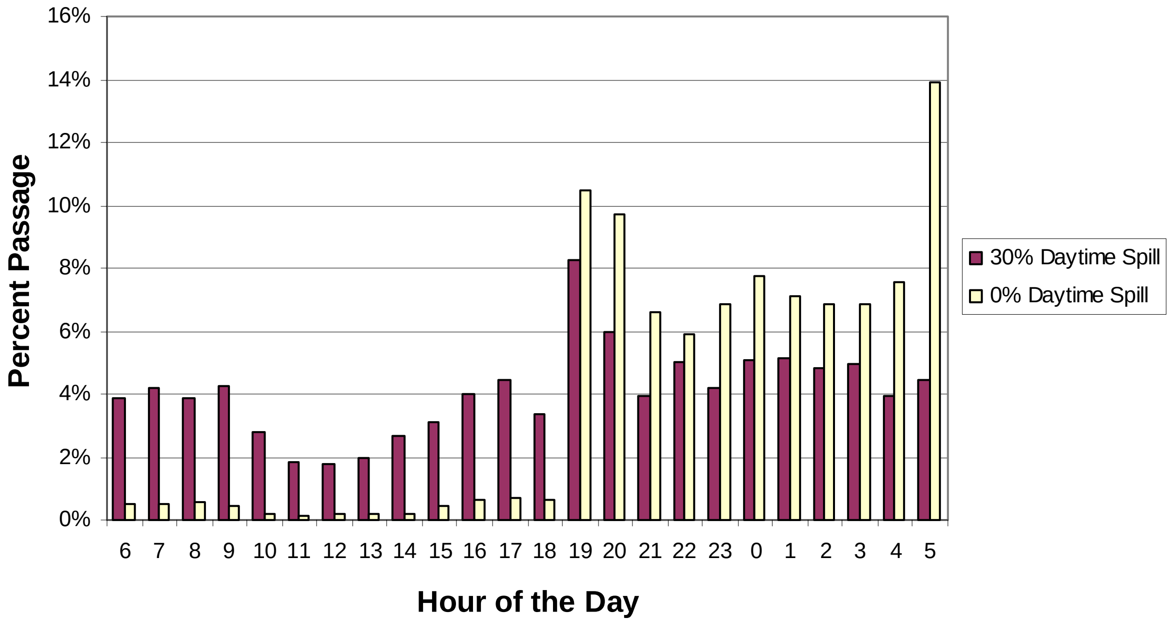

Figure 4.9. Diel Distribution of Spillway Passage at John Day Dam in Summer 2000

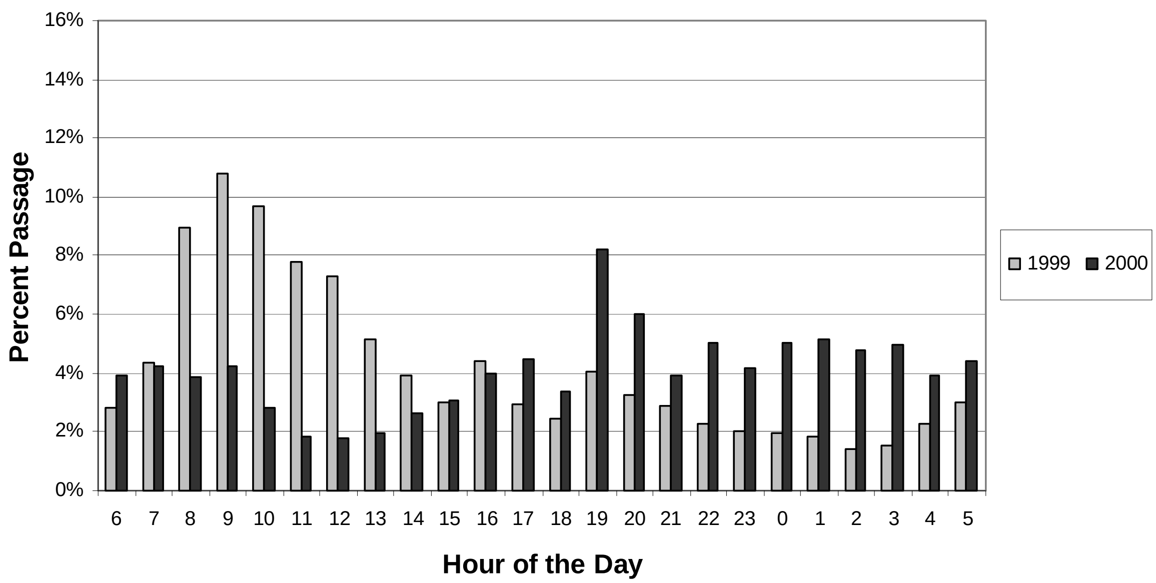

Figure 4.10. Diel Distribution of Fish Passage through the John Day Dam Spillway in Summer 1999 following Days with 30% Spill. (adapted from HTI 2000 and Moursund et al. 2001). Spillway passage represents 93% of total project passage in 1999 and 94% in 2000.

4.2.5 Spill Passage Efficiency and Spill Passage Effectiveness

From 1980 to 1989, hydroacoustic monitoring of spill passage was restricted to the nighttime period (2000-0600 h), and typically the summer migration season. Spill passage efficiency estimates during spring and summer periods ranged from approximately 20 to 40% and spill effectiveness ranged from 0.75 to 1.4 (Table 4.6). Daily estimates of spill passage efficiency and effectiveness demonstrate a broad range of values at a given spill proportion and demonstrate a general increase with increasing spill proportion (Figures 4.11 and 4.12). The relationship between spill efficiency and spill proportion is best depicted in the 1983 data set, due to the wide range of spill proportions. Spill efficiency generally increased with increasing spill volume up to approximately 50 kcfs and then showed a general decrease at spill volumes approaching 150 kcfs (Figure 4.12). Spill effectiveness values were widely distributed at lower spill proportion and discharge levels. Spill effectiveness demonstrated a slightly decreasing trend as spill proportion and volume increased (Figures 4.13 and 4.14). Spill passage efficiency demonstrated a decreasing trend over the range of spill proportions observed in 1998 and 1999 (BioSonics 1999; Johnston, Nealson, and Horchick 2000) (Figure 4.15).

Table 4.6. Mean Seasonal Spill Passage Efficiency/Spill Passage Effectiveness (spill passage efficiency/spill effectiveness) from Hydroacoustic Evaluations at John Day Dam, 1983-1989

Year	Time Period	
	Night Spring	Night Summer
1983[a]	0.39/0.79	0.40/1.04
1984		0.38/0.76
1985	0.21/0.75	
1986		0.32/1.04
1987		0.23/1.3
1988		0.19/1.1
1989		0.28/1.4

(a) Spill efficiency and effectiveness estimates for 1983-1985 were calculated from daily data contained in annual reports.

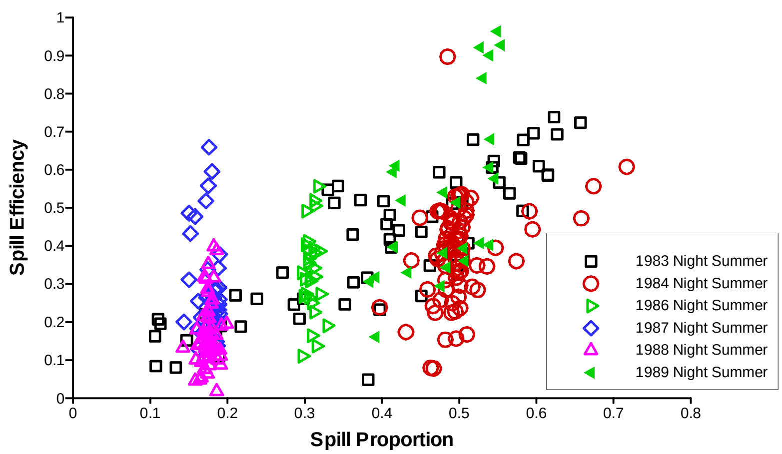

Figure 4.11. Hydroacoustic Estimates of Summer Nighttime Spill Passage Efficiency versus Spill Proportion for John Day Dam, 1983-1989

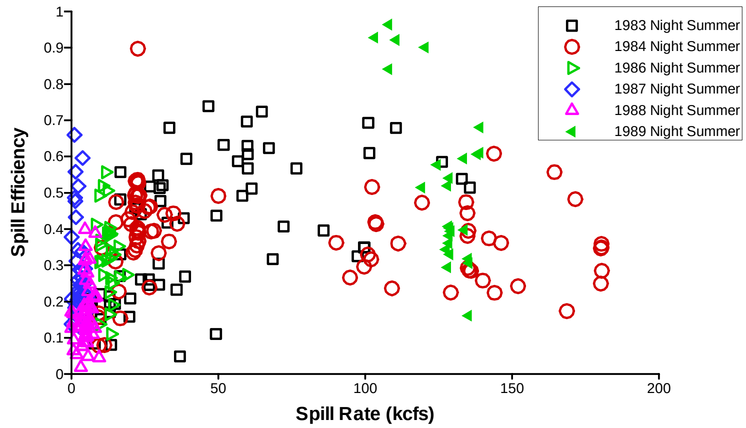

Figure 4.12. Hydroacoustic Estimates of Summer Nighttime Spill Passage Efficiency versus Spill Discharge (kcfs) for John Day Dam, 1983-1989

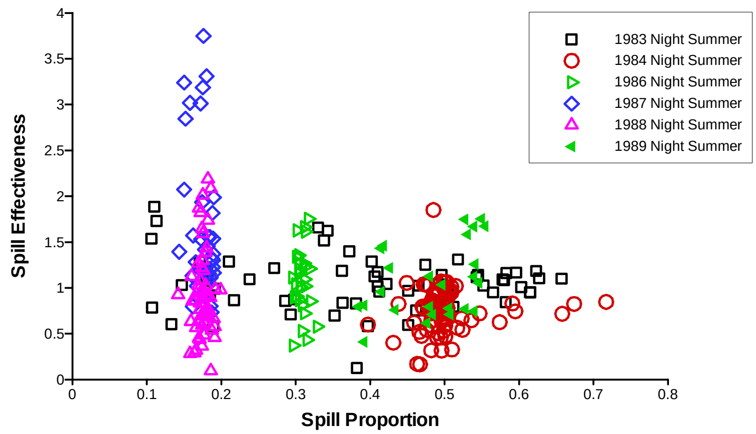

Figure 4.13. Summer Nighttime Spill Effectiveness versus Spill Proportion for John Day Dam, 1983-1989

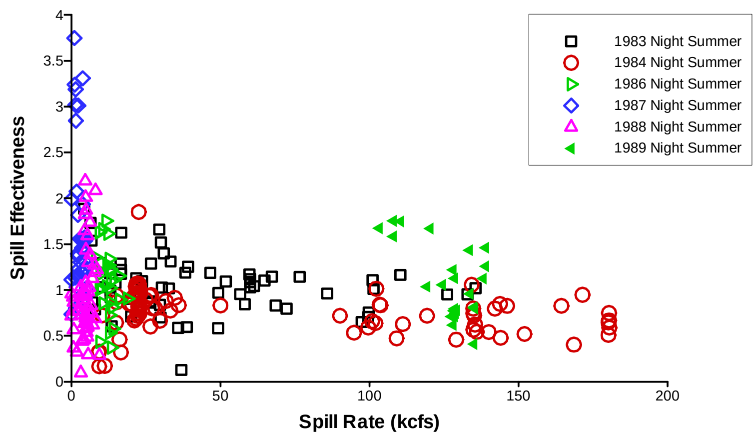

Figure 4.14. Summer Nighttime Spill Effectiveness versus Spill Discharge (kcfs) for John Day Dam, 1983-1989

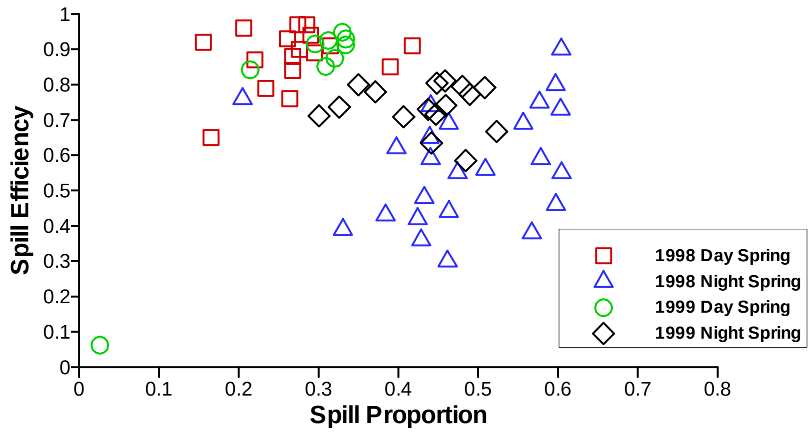

Figure 4.15. Day and Nighttime Estimates of Spill Passage Efficiency by Spill Proportion in Spring 1998 and 1999

Daily spill passage efficiency and effectiveness estimates in summer 1999 and 2000 demonstrated a wide range of values over the observed spill proportions (Figure 4.16). Spill efficiency decreased as spill proportion increased in 1999, but spill efficiency stayed the same when spill proportion increased in 2000. Spill effectiveness in 1999 and 2000 decreased with increasing spill proportion (Figure 4.17).

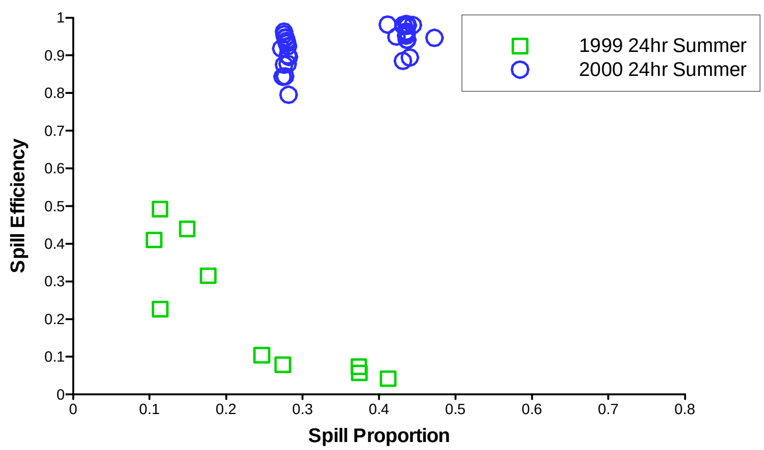

Figure 4.16. Daily Estimates of Spill Passage Efficiency by Spill Proportion in Summer 1999 and 2000

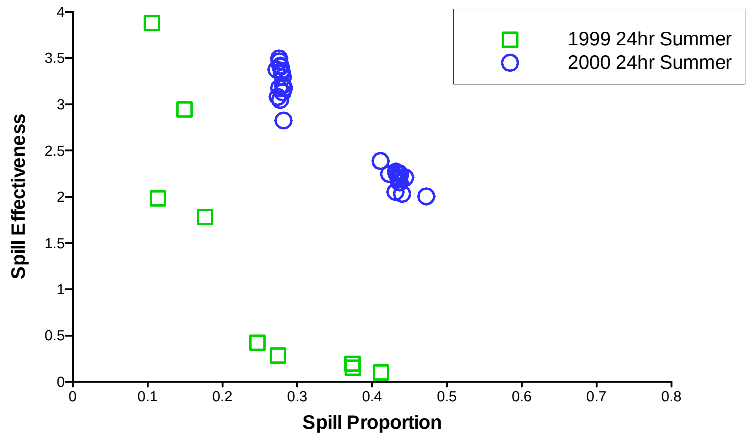

Figure 4.17. Daily Estimates of Spill Effectiveness by Spill Proportion in Summer 1999 and 2000

4.2.6 Effect of Dam Operations on Fish Spill Efficiency and Effectiveness

In 1980 and 1981, a test was conducted to determine if smolts could be guided toward the spillway by shutting down turbines sequentially from the south end of the powerhouse toward the north end, where the powerhouse and spillway intersect. However, the deep deployment location of the transducer at spill bay 20 was ineffective and no echo traces could be confidently identified as fish entering the spill bay (Magne, Nagy, and Maslen 1983). Additionally, fish densities at Turbine 16 during the two treatments tested were not significantly different at the 0.001 probability level. It was assumed that if the sequential load dropping did in fact redistribute fish, changes in fish density would be demonstrable at Turbine 16. In 1981, a comparison of shallow and deep spill was conducted at spill bay 16. Magne, Nagy, and Maslen (1983) reported that insufficient data was collected due to ineffective transducer orientations and problems associated with monitoring fish passage near the surface.

In 1997, experimental weirs were placed in spill bays 18 and 19 to provide a shallow, surface oriented outlet for fish passage. Accordingly, the hydroacoustic monitoring effort consisted of evaluating spill passage efficiency in spring and summer during weir “in” and weir “out” conditions (BioSonics 1999). In spring, the overall means of efficiency and effectiveness were significantly higher ($P=0.07$ and $P=0.06$, respectively) during the weir “out” condition (Table 4.7). Spillway passage was similar between the two treatments in summer ($P>0.10$). The overall efficiency and effectiveness of the surface oriented weir may have been suppressed in 1997 due to high volumes of water passing through other locations. Surface oriented bypasses such as overflow weirs may be most effective in lower flow conditions.

From 1998 through 2000, the spill program at John Day Dam focused on evaluating spill passage at different levels of daytime and nighttime spill (Table 4.8). In spring 1998, approximately 20 to 30% was spilled when daytime spill occurred, and between 35 to 60% of the river was spilled at night. In summer 1998, daytime spill was approximately 19% of inflow. In 1999 and 2000, daytime spill treatments were

Table 4.7. Spill Passage Efficiency (SPE) and Effectiveness Estimates for Weir "In" and Weir "Out" Conditions at John Day Dam, Spillbays 18 and 19, during Spring and Summer 1997. (Confidence intervals not available for spill effectiveness estimates.)

	Season			
	Spring		Summer	
Metric	Weir In	Weir Out	Weir In	Weir out
SPE	0.49 ± 0.03	0.56 ± 0.01	0.84 ± 0.02	0.86 ± 0.03
Spill Effectiveness	1.54	3.10	3.86	3.98

0% and 30% and at night spill was approximately 45% of inflow in 1999 and 53% in 2000. Daily estimates of spill passage efficiency and effectiveness were compared between days when daytime spill occurred and days when no daytime spill occurred.

In spring 1998, spill passage efficiency was higher on days when daytime spill occurred. This trend was also observed in spring 1999 (Table 4.8). However, in both years, spill effectiveness was higher on days when no daytime spill occurred. During the 1998 summer period, spill passage efficiency was higher for days when no spill occurred. In 1999 and 2000, the opposite pattern was observed, with spill passage efficiency being higher following days of daytime spill (Table 4.9). Spill effectiveness was higher for days when no daytime spill occurred for all three years. Mean hourly spill percentages over the 24-h period were used to calculate spill effectiveness.

Comparing nighttime spill passage efficiency between days with and without daytime spill is intended to address the question of whether or not smolts aggregate in the forebay under 0% daytime spill conditions. Nighttime spill passage efficiency may be higher following days of no spill if such an aggregation occurs. In spring 1998, nighttime spill passage efficiency was higher following days without spill, but there was no significant difference observed in 1999 (Table 4.10). Results from the 1999-2000 summer periods were mixed. In 1998, nighttime spill passage efficiency was higher following days without spill compared to 1999 and 2000 when nighttime spill passage was higher followings days with spill (Table 4.11).

Table 4.8. Proportion of Day and Night Spill (day/night) and Mean Daily Spill Passage Efficiency (SPE) and Effectiveness at John Day Dam, Spring 1998-1999. Day spill percentage were 0% and 27% in 1998 and 0% and 30% in 1999. Nighttime spill was 48% in 1998 and 45% in 1999.

	SPE 12-h	SPE 24-h	Spill Effectiveness 12-h	Spill Effectiveness 24-h
1998	00/48 Day/Night	27/48 Day/Night	00/48 Day/Night	27/48 Day/Night
	0.57	0.68	1.96	1.92
1999	00/45 Day/Night	30/45 Day/Night	00/45 Day/Night	30/45 Day/Night
	0.68	0.82	3.10	2.37

Table 4.9. Proportion of Day and Night Spill (day/night) and Mean Daily Spill Passage Efficiency and Effectiveness at John Day Dam, Summer 1998-2000. Day spill percentage were 0% and 27% in 1998 and 0% and 30% in 1999 and 2000. Nighttime spill was 48% in 1998 and 45% in 1999 and 53% in 2000.

	SPE 12-h	SPE 24-h	Spill Effectiveness 12-h	Spill Effectiveness 24-h
1998	00/47 Day/Night	19/47 Day/Night	00/48 Day/Night	27/48 Day/Night
	0.57	0.41	1.93	1.85
1999	00/45 Day/Night	30/45 Day/Night	00/45 Day/Night	30/45 Day/Night
	0.63	0.93	4.75	2.76
2000	00/53 Day/Night	30/53 Day/Night	00/53 Day/Night	30/53 Day/Night
	0.64	0.94	3.35	2.22

Table 4.10. Spill Passage Efficiency in Spring of 1998 and 1999 for Days without and with Daytime Spill

Spill Passage Efficiency					
	Day	Night		24-h	
	With Day Spill	Without Day Spill	With Day Spill	Without Day Spill	With Day Spill
1998	0.89	0.64	0.51	0.57	0.68
1999	0.91	0.76	0.73	0.68	0.82

Table 4.11. Spill Passage Efficiency in Summer of 1998-2000 for Days without and with Daytime Spill

Spill Passage Efficiency					
	Day	Night		24-hr	
	With Day Spill	Without Day Spill	With Day Spill	Without Day Spill	With Day Spill
1998	0.81	0.57	0.41	0.50	0.61
1999	0.97	0.70	0.82	0.63	0.93
2000	0.97	0.94	0.95	0.91	0.96

4.2.7 Fish Guidance Efficiency

The use of hydroacoustics to evaluate intake screen performance at John Day Dam is currently limited to research conducted in 1996. In 1996, hydroacoustics were used to evaluate the fish guidance efficiency (FGE) of an intake screen in turbine intake 7b. An average FGE of 92% ± 4% was reported for the spring study and 75% ± 4% was reported for the summer study (BioSonics 1997). Ploskey and Carlson (1999) conducted a comparison of hydroacoustic net estimates of FGE based on the 1996 data set. They reported that the precision of hydroacoustic estimates increased 50% and the r^2 of the correlation line increased 19% when the hydroacoustic sampling duration was increased from 1 or 2 h to 4 h. The best correlation between net and hydroacoustic FGE estimates (r^2 = 0.85;N=40) had a slope of 0.91 with the intercept set to zero. Minimum and maximum estimates of FGE currently used by the NMFS are 54% and 78% for yearling chinook salmon, 65% and 87% for steelhead, and 13% and 55% for subyearling chinook salmon. Estimates of FGE were similar between fyke net (Krmca et al. 1986; Brege et al. 1987; Kransow 1998) and radio-telemetry studies (Hansel et al. 1999).

5.0 Fish Survival

Published smolt survival estimates for the John Day Project are limited and inadequate for making informed management decisions. The estimates are either dated or not representative of current dam configurations and operating conditions (Raymond and Sims 1980), or they are probative or preliminary in nature (Counihan et al. 2000).

In 1979, the NMFS conducted turbine and spill survival evaluations at John Day Dam (Raymond and Sims 1980). There were two treatments, turbine passed fish and fish passed through surface spill. Control groups were released two miles downstream from a barge approximately 30 m offshore on both sides of the river. Freeze-branded hatchery fall chinook salmon were released through the passage routes via 10 cm-diameter hose. Marked fish were recovered at The Dalles Dam. Test release locations were turbine Unit 5 and spill bay 16 fitted with stop logs. NMFS estimated that 87.1% (±5.5%) of the fall chinook salmon passing through that turbine survived from the point of release to the control release site, two miles downstream. The 95% confidence interval was 81% to 92% survival. They reported that spill bay survival was not statistically different from 100%.

The relevance of those estimates to contemporary conditions is questionable. Since conducting that study, a spill program has been formulated for the project, turbines are operated near peak efficiencies, and predator removal efforts have been implemented. The latter activity could affect mortality reflected in the 2-mile zone below the dam and upstream of the control release.

In 1999, the USGS conducted a study to examine the feasibility of extracting survival information from radio telemetry studies of juvenile salmon at John Day and The Dalles dams (Counihan et al. 2000). Survival probabilities were estimated using the release/recapture models of Burnham et al. (1987). The results indicated that using radio-tagged yearling chinook salmon and steelhead to estimate survival probabilities is feasible and resulted in survival estimates with relatively high precision given the low numbers of fish tagged and released in the 1999 study. Relative survival estimates were 93% (SE 0.38) for steelhead and 99% (SE 0.03) for yearling chinook salmon, from Rock Creek to the release location of control fish in the tailrace of John Day Dam (see page 32 in Counihan et al. 2000). They used relative survival estimates for study design considerations, but recommended that the absolute survival values be viewed in the context of the preliminary nature of the study. They also indicated that the release design and various tagging protocols used during 1999 would need to be altered to ensure that assumptions of survival models are satisfied.

These survival estimates are not particularly useful for characterizing passage effects at John Day Dam. By virtue of the release locations, they do not accurately reflect population survival probabilities past the dam. Tailrace reference groups were released near the bypass outfall. Any outfall effects could be reflected in the relative survival estimates. Again, the authors emphasize that this was a feasibility study with capture probabilities being the performance measures of interest. There was no stated objective to estimate either project or dam survival at John Day Dam.

In 2000, USGS continued survival studies in the lower Columbia. One objective was to estimate smolt survival at John Day Dam. A draft report was not available for review, but preliminary results were presented at a survival workshop held in November 2000 at NMFS in Seattle. Using radio telemetry and a paired release model they estimated smolt survival at John Day Dam during two spill scenarios. Only spillway survival estimates were presented. They found that when all spill occurred at night at 53% spill both steelhead and yearling chinook salmon survived at high rates, from 98.6% to 98.9% survival. However, with the same night spill level plus a 30% spill provided during the day, survival plummeted to 90.6% to 93.5% for each species, respectively. Error bounds associated with those point estimates were broad, so it may be difficult to assess whether the differences were significant (the investigators did not discuss this). Nevertheless, the decrease was evident for both species, suggesting real effects are implicated. The situation certainly warrants further investigation.

In summary, the smolt survival estimates available from this dam are too sparse to even generally characterize passage impacts. Consequently, confidently devising an effective passage program for this site will be difficult. As witnessed at The Dalles Dam there are no typical passage route survival estimates that can be applied across dam sites. Furthermore, it is necessary to evaluate both direct and indirect effects.

6.0 Discussion

6.1 Data Limitations and Uncertainties

Limitations, uncertainties and inconsistencies in the radiotelemetry, hydroacoustic, and survival data for fish passages at John Day Dam over the past 20 years are discussed below. Tables 7.3 and 7.4 in Section 7.0 summarize what data is and isn't available for each study year.

6.1.1 Radio Telemetry

The single greatest limitation for most radio telemetry studies is that the relatively low number of tagged fish released does not permit daily or even weekly estimates for most passage estimates. This becomes an important concern if numbers must be apportioned among operational treatments that change over time steps of days or weeks, as well as assorted passage routes. For example, sample sizes of radio-tagged juveniles were only large enough to discern differences in forebay residence times during spill tests and diel periods in 1999 and 2000. The lack of variance estimates attending passage-related responses makes it difficult to identify true statistically significant differences among treatments. Also, transmitters can only be implanted in the larger sized individuals within a population of smolts. With extensive antennae arrays like those used in 1999 and 2000, tag detections usually exceed 95%, so tag detection seldom is limiting factor in fact it is one of its strongest and compelling attributes in mark-recapture survival models. Another limitation associated with telemetry in general is the inability to clearly define the size of detection zones, particularly using aerial systems. A shallow tag can be detected at a far greater horizontal distance than one at depth. Furthermore aerial systems have a maximum detection depth of 7.6 to 9.1 m, under water conductivity levels that prevail in the Columbia River. Underwater antennas have a much more localized, uniform, albeit compact detection field, generally scribing a sphere with a radius ranging from about 6.1 to 9.1 m depending on conductivity.

Another potential limitation of radio telemetry is uncertainty about the extent to which tagging, handling, tag presence, and release affect the health, behavior, and distributions of tagged fish. Radio telemetry studies use has an explicit assumption that tagged fish behave the same as untagged fish, and researchers go to considerable lengths to ensure that effects are minimized. For example, the USGS has been diligent in conducting a battery of laboratory studies to investigate tag effects on host fish (e.g., Adams et al. 1998a; Adams et al. 1998b; Martinelli et al. 1998). Based on those tests they have identified the minimum-sized fish that can readily accommodate miniaturized radio tags of various mass. Nevertheless, it may be desirable to conduct special studies to compare vertical distributions of radio-tagged fish to vertical distributions of run-of-river fish to determined whether significant differences exist that might differentially affect the fate of tagged and untagged fish. Vertical distributions could be determined by using depth sensitive tags or acoustic tags for tagged fish, and hydroacoustics could be used to sample the vertical distribution of untagged fish. If untagged fish migrated deeper than tagged fish, then they may be more likely to pass through turbines than through a sluiceway or spillway.

6.1.2 Hydroacoustics

Due to changes in transducer placement, transducer type, and data collection and analysis procedures among years, comparisons of fish passage efficiency metrics from hydroacoustic evaluations at John Day Dam are limited. For example, from 1980 to 1989 15º transducers mounted upstream of turbine trash-racks were used to monitor powerhouse passage. Beginning in 1997, 6º transducers were placed in-turbine to provide the same information. Data collected from 1980 to 1989 are comparable since similar deployments were used among years. However, the aiming angle of the powerhouse transducers brings into question the final fate of fish that passed through the sample volume. Transducers were typically mounted at the bottom of the pier noses, approximately 43 m below the surface at normal pool elevation of 80 m MSL, and were aimed 30º upstream from the trashrack plane (Magne, Bryson, and Nagy 1987; McFadden and Hedgepeth 1990). In this deployment, the downstream extent of the acoustic beam is approximately 17 m upstream of the face of the dam at the surface and approximately 9.7 m upstream of the top of the trashracks. The low water velocity within the sample volume and the distance upstream from the trashracks likely results in fish passing through the hydroacoustic beam, but not passing into the associated turbine intake. Powerhouse passage estimates may therefore overestimate turbine passage while in this deployment configuration. Samples collected in-turbine more accurately represent turbine passage because fish are entrained or committed to this passage route due to the higher water velocities.

Along with differences in transducer location among years, system set-up parameters such as pulse-repetition rate, fish-detection threshold, and fish-tracking criteria have been modified over the data collection period. Fish-detection thresholds used from 1980 to 1985 were 4 to 7 dB higher than those used during more recent studies. Higher fish-detection threshold would result in the exclusion of tracks from smaller fish. In 1997, BioSonics (1999a) used a fish-detection threshold of –50 dB while the spillway weir was in place and –58 dB with the weir removed. They did report that post-season comparisons between the two fish-detection thresholds did not affect data quality. Pulse repetition rates for transducer sampling powerhouse or spillway locations have also varied widely over the years. A pulse repetition rate of 12 pings/second was used for sampling turbine locations from 1980 to 1981. From 1984 to 1989, with the transducers mounted in the same location, a pulse rate of 4 or 5 pings/second was used. Pulse rates of 20 (1999) and 12 (2000) pings/second have been used most recently for in-turbine transducer deployments (Johnston, Nealson, and Horchik 2000; Moursund et al. 2001). Pulse-repetition rates used at spillway locations were 12 ping/second in 1980 (Magne, Nagy, and Maslen 1983) and in 2000 were 24 pings/second (Moursund et al. 2001).

Due to the vertical gradient in water and fish velocity within a spill bay, estimation of spillway passage continues to present challenges. Water velocity near the surface may be as low as 0.6 m/second compared to 2.4 m/second at the ogee. This difference in water velocity results in large differences in detectability throughout the water column. An additional problem associated with enumerating spillway passage is classifying surface targets as passing through the spillbay. An assumption must be made that targets detected near the surface descended rapidly to pass at the ogee. Recently, transducers have been deployed closer to the tainter gates and pulse-repetition rates increased to improve detectability and provide more reliable estimates of spillway passage.

Another factor that can create sizable differences in results of hydroacoustic studies is how technicians processed echograms to extract fish traces. Three years of data from processing echograms from The Dalles and Bonneville Dams indicate that different trained technicians can produce markedly different counts from the same hydroacoustic data sets (Figures 6.1 and 6.2). Greater individual differences are associated with higher levels of structure and acoustic noise. Even extensive training, including tracking large data sets as individuals and then tracking the same data sets again as a group, did not reduce differences to acceptable levels. Trackers with multiple years of experience and using the same explicit criteria had large differences in fish counts from the same noisy data sets. The problem is too pervasive to be resolved by spot-checking a small sample of the data. The inter-tracker bias can be especially serious if different individuals are assigned different hydroacoustic systems or passage routes since human differences accumulate over time to bias results and conclusions. Automated tracking, carefully and frequently calibrated to the average of several trained human trackers, can provide cost effective analysis free of unavoidable human bias. If automated tracking is not possible then within hour or hourly data from all passage routes must be distributed among technicians so that individual differences are averaged over the smallest possible time step.

6.1.3 Survival

Survival estimates suitable for characterizing passage effects at John Day Dam are inadequate. Only one year of telemetry based estimates are available. The estimates are sound and follow generally accepted protocols. However, the effort will need to be repeated in additional years to have confidence in

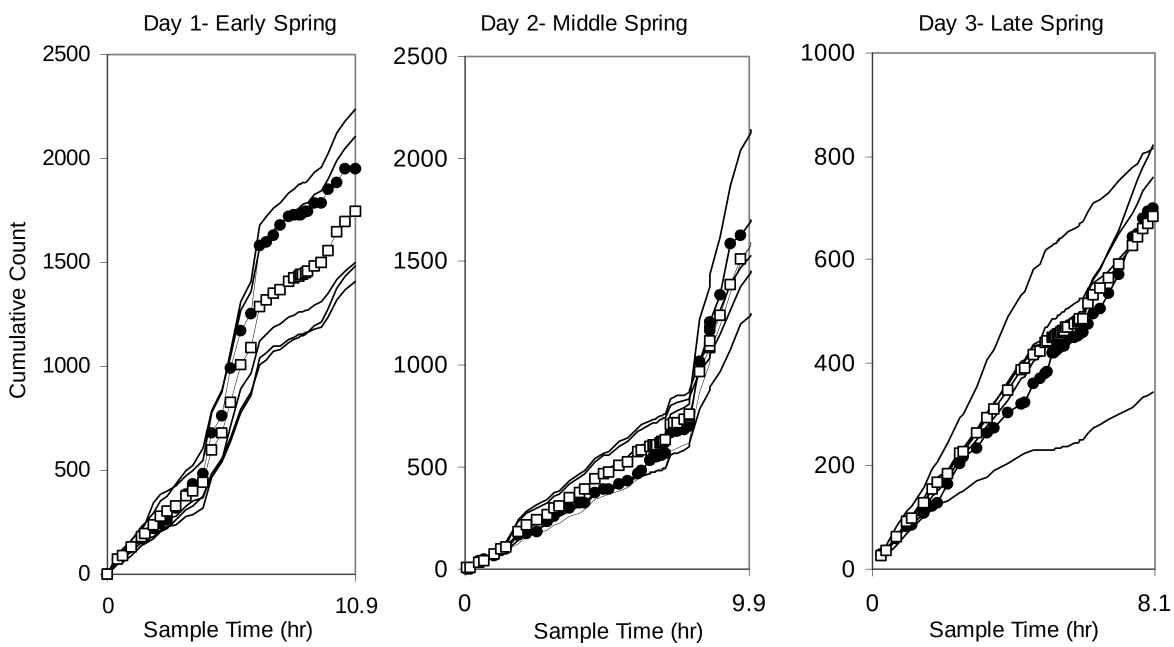

Figure 6.1. Three Examples of Cumulative Counts by Human Trackers (lines are individuals; open squares are the mean) and by an Autotracker (line with black dots)

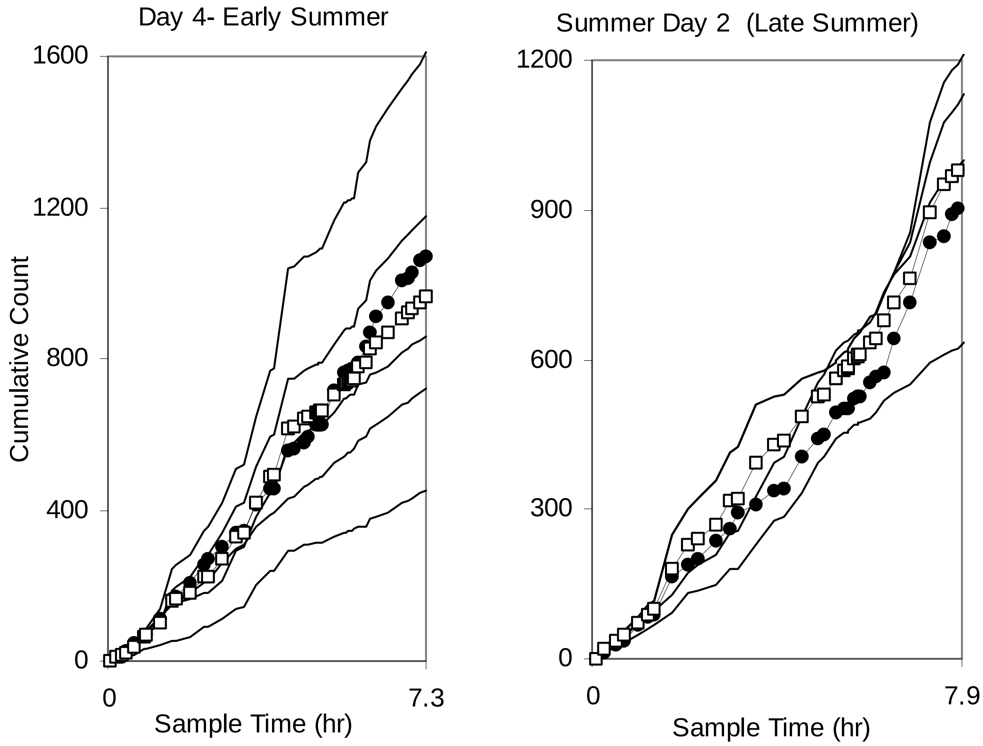

Figure 6.2. Two Examples of Cumulative Counts by Human Trackers (lines are individuals; open squares are the mean) and by the Autotracker (line with black dots)

these estimates being representative. The passage route-specific estimates suffer from a limitation commonly encountered, the variances associated with the survival estimates are rather broad. The only way to improve precision is to increase the numbers of tags released. If radio telemetry systems are used to estimate route specific-survival in the future, investigators may want to consider employing a dual sampling systems at each passage route, similar to that described in Stevenson et al. (2000). Those investigators found that at Rocky Reach and Rock Island dams the dual system permitted the use of an alternative analytical model, with improved estimation capabilities particularly at Rock Island Dam. The efficacy of the technique for improving the quality of estimates appears to be site specific.

6.2 Consistencies and Differences between Methods

Comparisons of radio telemetry and hydroacoustic results from juvenile fish passage evaluations at John Day Dam are realistically limited to data collected in spring 1999. In 1997 and 1998, both techniques were used at John Day Dam, but low sample sizes of tagged fish and detectability concerns within the hydroacoustic data set preclude any worthwhile comparison of spill passage efficiency.

In 1999, both techniques were used to evaluate fish passage during the spring outmigration period. Two daytime spill levels, 0% and 30%, were each combined with 45% nighttime spill to evaluate the most effective project operation for fish passage. Pooled radio telemetry estimates indicated that mean daily spill passage efficiency was 49% with no daytime spill and was 59% for days with spill. Results from the concurrent hydroacoustic evaluation were dissimilar. Mean daily spill passage efficiency was reported to be 63% under the 0% daytime spill treatment and 93% for days when spill occurred. Even though SPE estimates were not identical, both techniques indicated that spill efficiency had increased over past years and SPE was higher for the 30% daytime spill treatment. Ideally, both techniques would yield similar performance values. However, the disparity between the two techniques serves as an indicator that further investigation is warranted. Investigation of the number of locations monitored, deployment orientation of antennas or transducer, sample frequency, and analysis algorithms all result in improvements in determining passage metrics. With only one gear type, a direct comparison is not available.

Comparing results from concurrent radio telemetry and hydroacoustic studies is useful. However, if the comparisons are to be truly meaningful or legitimate, the comparisons need to be part of the overall study design. It is not enough to collect data simultaneously and then put both sets of numbers into a report and see how they compare. By integrating study designs, we will increase the strength of the comparisons and in turn improve the science of estimating juvenile fish passage.

We believe that the use of both radio telemetry and hydroacoustics to determine Project-wide fish passage performance is much more desirable than using either method alone because the two methods are more complementary than redundant (see Tables 6.1 and 6.2). Over the years, calculation errors have been caught after differences were identified in estimates by the two methods. For example, the 1998 hydroacoustic estimates of fish passage efficiency through 6.1-m-wide prototype surface collector slots at Bonneville Powerhouse 1 were significantly lower than estimates from radio telemetry and those differences led the hydroacoustic researchers to double check all spatial and temporal expansions. An error in the hydroacoustic estimate for the 6.1-m slot resulted from using the same spatial expansion factor for both 6.1- and 1.5-m slots. In 2000, preliminary radio telemetry estimates of PSC fish passage efficiency were about 50% until differences between hydroacoustic estimates, acoustic tracking, and radio telemetry estimates were compared and questioned. Correction of a calculation error in the radio telemetry estimates brought all estimates within 10% of each other. Estimates by both methods are very complicated to make and need careful scrutiny to ensure accuracy. Having independent estimates is the best way to ensure the reliability of conclusions and to identify potential biases in either method.

Table 6.1. Sampling Attributes for Fixed-Aspect Hydroacoustics and Radio Telemetry Studies at John Day Dam

Sampling Attribute	Hydroacoustics	Telemetry
Species specific	No	Yes (whatever is tagged)
Travel and residence Time	No	Yes
Detectability	High within but low among sample volumes	High
Route specific passage	Proportions and Passage Estimates	Proportions only
Route specific survival	No	Yes
Number of observations	>300,000	<3,000
Inference	All Fish	Tagged fish
Spatial resolution	High within but low among sample volumes	Low
Track length	<2 m	100s of m
Vertical distribution data	Yes	No
Run timing	Yes (data are continuous)	No
Diel timing	Yes (data are continuous)	Depends on release/arrival times
Behavior	Fine scale	Broad scale
Invasive	No	Yes (whatever is tagged)

Table 6.2. Strengths and Weaknesses of Hydroacoustic and Radio Telemetry Methods

Hydroacoustic Strengths	**Radio Telemetry Strengths**
1. Samples detect hundreds of thousands of run-of-river fish 2. Permits estimates of proportions of fish passing different routes 3. Permits expansion to numerical passage estimates for structures and projects 4. Relatively high spatial resolution within sample volumes. Many different centimeter-scale ranges (single-beam) or 3-D positions (split-beam or multi-beam) per second 5. Noninvasive 6. Time (seasonal and diurnal) and route of passage unaffected by release time and place	1. Certainty of fish identity 2. Permits estimates of proportions passing different routes 3. Provides travel times 4. Each antenna interrogates a relatively large water volume 5. Tag identity is unambiguous 6. Can provide route specific survival estimates
Hydroacoustic Weaknesses	**Tagging Weaknesses**
1. Inherent ambiguity of fish identity 2. No travel time or survivorship data 3. Each transducer interrogates a relatively small water volume (except for multi-beam) 4. Requires assumptions about detectability and detectability modeling to adjust spatial expansions 5. Acoustic noise, especially echoes from entrained air, can obscure fish and affect detectability 6. Detection depends on trace identification and selection by a person or program	1. Data are collected on relatively fewer (hundreds to several thousand) fish. 2. Relatively low spatial resolution (meter or larger-scale position every few seconds) 3. Invasive 4. Tagging, tag presences, transport, and release may affect behavior such as vertical distribution that could influence estimates of fish passage metrics 5. Passage time (seasonal and diurnal) and route may be affected by release time and place 6. Does not permit expansion to numerical passage estimates for structures and projects

7.0 Conclusions and Recommendations

7.1 Conclusions

Conclusions from our review of the radio telemetry and hydroacoustic studies on fish behavior and fish passage at John Day Dam Between 1980 and 2000 are summarized below.

7.1.1 Summary of Fish Behavior

- Radio-telemetry conducted upstream of John Day Dam indicated that spring steelhead and yearling chinook salmon typically migrated along the northern (Washington) shoreline of the river. Both species also avoided the John Day River plume, suggesting either avoidance or being pushed to the north shore by the discharge. Summer migrants (subyearling chinook salmon) were typically distributed along both the north and south shorelines as they approached the dam and appeared to be less affected by discharge from the John Day River.

- Data related to location of first entry into the John Day Dam forebay appeared mixed. Results from research conducted in 1995 to 1997 suggest first entry location may be a function of project discharge (i.e., fish approach the structure where the most discharge is occurring). However, in 1998 powerhouse passage remained high even with relatively high levels of spill discharge. Differences between the two time periods may be related to differences in study design, river/test conditions, and behavior of fish.

- In general, yearling chinook salmon and steelhead that arrived in the forebay when no spill occurred tended to delay. Yearling chinook salmon and steelhead that arrived at night, concurrent with spill, passed the dam more readily. Residence times for yearling chinook salmon were markedly reduced with daytime spill, whereas steelhead residence times decreased slightly in the presence of daytime spill. When daytime spill went from 0% to 30% yearling chinook salmon residence time dropped from 8.5 h to 0.8 h in 1999 and 9.0 h to 2.4 h in 2000, while yearling steelhead residence time decreased from 11.4 to 11.3 h in 1999 and 11.4 to 9.4 h in 2000. There is some suggestion from data collected in 1999 and 2000 that hatchery steelhead (>200 mm) may delay in the John Day Dam forebay longer than wild steelhead (<200 mm).

- Descriptions of forebay fish distributions at John Day Dam are most appropriately used to describe potential milling behavior and lateral movement rather than actual routes of passage.

- Egress from the tailrace was quickest in 1998 for fish that passed through the southern portion of the spillway. In 2000, mean tailrace residence times of yearling and subyearling chinook salmon that passed through the bypass were highest during high levels of nighttime spill.

- Predation on migrating juvenile salmon may be exacerbated by either forebay or tailrace delay. Increased residence times will concentrate smolts potentially attracting predators.

7.1.2 Fish Passage

7.1.2.1 Radio Telemetry Results

- From 1984 through 1998, a general comparison may be made for SPE and spill effectiveness, when spill percent was similar (ranging from ~33-43%). Both SPE and spill effectiveness varied little among years, seasons, or species, with SPE ranging from 52% for yearling steelhead in the spring of 1998 to 77% for subyearling chinook salmon in the summer of 1998, with an overall average of about 60%. Spill effectiveness ranged from 1.2:1 for yearling steelhead in the spring of 1998 to 1.9:1 for yearling chinook salmon in the spring of 1997, with an overall average of about 1.6:1. Spill effectiveness was similar between 1999 and 2000. Steelhead spill effectiveness was 1.6:1 and 2.3:1 during the 12-h spill and 1.1:1 and 1.4:1 during the 24-h spill, in 1999 and 2000 respectively. Yearling chinook salmon spill effectiveness was 3.0:1 in 1999 and 2.4:1 in 2000 during the 12-h spill and 1.4:1 for both years during the 24-h spill.

- In examining the results of the 12-h vs. 24-h spill tests in 1999 and 2000 at John Day Dam, we conclude that the use of 24-h spill slightly increases the SPE of steelhead yearlings and increases SPE for yearling chinook salmon, but does not substantially improve FPE for either species compared to the 12-h spill. Even though the addition of day spill (24-h spill) did not improve FPE, it was beneficial to both steelhead and juvenile chinook salmon by reducing forebay residence times, which may have benefits to their fitness and survival (see Section 3 above).

- Diel behavioral responses (species specific) to dam operating conditions made it difficult to detect differences in FPE at John Day Dam. Radio-tagged fish, especially steelhead arriving at the dam during 0% or 30% day spill conditions, almost always delayed passing until night. Therefore, with the great majority passing at night, the sample sizes for day FPE or SPE estimates are often very low and the day metrics are difficult to interpret.

- The slightly higher spill at night in 2000 (53%) compared to 1999 (45% spill) accounted for the SPEs that were 14% to 27% greater in 2000.

7.1.2.2 Hydroacoustic Studies of Fish Passage

- Hydroacoustic data collected from 1980 to 1989 were intended to address nighttime spill efficiency and effectiveness. Hydroacoustics at the beginning of this time period was still in the process of being investigated as a tool to measure relative fish passage among the various routes of passage. Data within this time period are comparable and spill passage efficiency demonstrates the expected trend of peak efficiency at intermediate spill levels; however, differences in transducer locations, pulse-repetition rates, and detectability concerns preclude comparison with more recent data sets. More recent applications (1996-2000) of hydroacoustics at John Day Dam have focused on providing estimates of spillway efficiency, effectiveness, powerhouse passage, and fish guidance efficiency of intake screens.

- The use of hydroacoustics to evaluate intake screen performance at John Day Dam is currently limited to research conducted in 1996. Minimum and maximum FGE estimates of FGE currently used by the NMFS are 54 and 78% for yearling chinook salmon, 65 and 87% for steelhead, and 13 and 55% for subyearling chinook salmon. Estimates of FGE were similar between fyke net (Krmca et al. 1986; Brege et al. 1987; Kransow 1998) and radio-telemetry studies (Hansel et al. 1999).

- Horizontal distribution of fish passage appear to be largely influence by project operations. Fish passage was highest through spillway and powerhouse locations that passed the most water.

- When only nighttime hydroacoustic monitoring occurred, passage was highest during the early evening hours (2000-2300 h). Twenty-four hour estimates of passage in 1999 indicated passage was highest from 0700 to 1300 h. Passage rates through the spillway were more evenly distributed in 2000, with only slightly elevated passage rates occurring around 1900 h.

- Trends in SPE estimates when compared to spill proportion and volume from available datasets (1983 to 2000) varied widely. From 1983 to 1989, SPE generally increased with increasing spill proportion as opposed to that observed in 1999 when SPE decreased as spill proportion increased. Data from 2000 indicates that SPE was similar between the two spill levels tested.

- In spring 1998 and 1999, daily SPE was 68% (1998) and 82% (1999) for days with daytime spill and 57% (1998) and 68% (1999) for days without daytime spill. In summer 1998, SPE was higher for days without daytime spill, 57% versus 41%. In 1999 and 2000, SPE was significantly higher for days with 30% spill compared to days with no daytime spill. In both years, SPE was approximately 93% for 30% spill days and 63% for no spill days.

7.1.3 Data Limitations

- The statistical rigor which exists in current fish passage evaluations precludes the use of much of the radio-telemetry and hydroacoustic data collected over the years at John Day Dam. Much of the early work focused on evaluating the efficacy of a sampling technique or monitoring trends in fish passage. Only within the last couple of years have research efforts been directed at determining route-specific survival and fish passage efficiencies.

- Due to the relatively low numbers of tagged fish released, daily or perhaps even weekly estimates of passage are unavailable for the majority of years. Sample sizes of radio-tagged juveniles were only large enough to discern differences in forebay residence time during spill tests and diel periods in 1999 and 2000.

- Changes in transducer placement and type, along with changes in analyses procedures, limit the comparability of fish passage efficiency metrics from year to year. Refinements in transducer analyses procedures and deployments, which have occurred over the last three years, have provided researchers with passage estimates appropriate for evaluating differences in fish passage among treatments and years for those years.

- Data related to survival of juvenile salmon passing through John Day Dam to date are too sparse to even generally characterize passage impacts.

7.2 Recommendations

A general recommendation for concurrent radio-telemetry and hydroacoustic research activities at John Day Dam is to coordinate study designs where practical so resulting data can be cross-checked and integrated.

We recommend that sample sizes of tagged fish for future radio-telemetry research be large enough to detect significant differences among key passage and behavior metrics. Improvements in tag detection by underwater antenna arrays is recommended. We also recommend that radio-telemetry data collection and analyses protocols be standardized.

For the hydroacoustic aspect of fish passage evaluations, we recommend methods used in 2000 become a starting point for future fish passage studies at John Day Dam. Detectability modeling using empirical data on parameters such as fish trajectory, fish speed, and target strength for each unique location is recommended. The standardization effort initiated by the District in 2001 is an important step in refining analyses and processing techniques that will then provide for comparability in future years.

With respect to survival estimates, we recommend that the District continue evaluating project, dam- and route-specific survival techniques to perfect methods for use at John Day Dam forebay and tailrace as a whole.

7.2.1 Data Collection and Management

A general recommendation for any future studies conducted at John Day Dam would be to include hourly flow information. Project operations data can be readily incorporated in every report on John Day Dam if hourly flow estimates through every turbine and spill bay were included in an appendix and in electronic form on a compact disk. The hourly flow estimates could easily be included in an appendix of radio telemetry and hydroacoustic reports along with hourly fish passage data after interpolation to un-sampled units and spill bays. Radio telemetry data are not always available for every hour of the day and therefore it may not be as logical to merge them with hourly operations data. Providing hourly flow information will facilitate future metadata analysis efforts.

7.2.1.1 Radio Telemetry

Spill efficiency as determined by radio-telemetry studies has several advantages and disadvantages when compared to spill efficiency as determined by hydroacoustic methods. Advantages include the ability to separate species (e.g., steelhead and chinook salmon, which often have different passage behaviors) and the ability to collect passage behavior data in the forebay and tailrace out away from the project. Disadvantages include are small sample sizes for radio telemetry studies, which means that often data must be pooled across dates and even species to have enough statistical power to detect significant differences. Also radio telemetry cannot be used for collecting data over a long, continuous period as hydroacoustics can.

Recommendations for improving data collection and management and analysis of data include

- Make sure that sample sizes of tagged fish are large enough to detect significant differences among key passage or behavioral metrics.

- Improve detection arrays of underwater antennas so probability of missing tagged fish is almost eliminated.

- Work toward standardizing study design (e.g., antenna location) so year to year comparisons may be made.

- Make sure study designs are coordinated with other concurrent research studies so resulting data can be cross-checked and integrated.

7.2.1.2 Hydroacoustics

We recommend that the methods used in 2000 become a starting point for future hydroacoustic fish passage studies at John Day Dam. In 2000, considerable effort was put into improving passage estimates through incorporation of location specific fish velocity, trajectory, and target strength estimates. However, estimation of spillway passage is an area that requires further effort to improve passage estimates. The variability in water and fish velocity from the waters surface to the spill ogee, demands that alternative spillway transducer deployments be investigated to better address the variability prior to further research at John Day Dam. Hydroacoustic sampling equipment and methods have improved over the last 20 years and transducer deployments have evolved over time so that data collected in later years is not directly comparable to data collected in early years. It is absolutely imperative that future studies acquire and process data in a consistent manner so that future syntheses of reports and analysis of metadata include more years than were available in this report. Because sizable differences in results have been attributed to how technicians process the echogram to extract fish traces we recommend automate tracking, carefully and frequently calibrated to the average of several trained human trackers, can provide cost-effective analyses free of unavoidable human bias. If automated tracking is not possible then within hour or hourly data from all passage routes must be distributed among technicians so that individual differences are averaged over the smallest possible time step.

The standardization of data processing software that was initiated by the District in 2001 is an important step in providing for data comparability in future years. Other recommendations for improving sampling and data processing for various passage routes at John Day Dam are presented in Table 7.1.

Table 7.1. Recommended Procedures for Future Hydroacoustic Sampling at John Day Dam

<table>
<tr><th>Recommendation</th><th>Turbines</th><th>Spillway</th></tr>
<tr><td>Coverage</td><td>Randomly sample at least 1 of 3 intakes at every turbine</td><td>Sample at least 50% of operational spill bays and preferably every spill bay to avoid interpolation</td></tr>
<tr><td>Deployment</td><td>In turbine from aimed upward 25 degrees off of the trash-rack plane from the bottom of the 5th trash rack. Aimed downward 20 degrees off the trash rack plane from the middle of the first trash rack.</td><td>Under deck plates with transducers aimed 8 degrees downstream of vertical so that detected fish >2.3 m from transducers are entrained when counted.</td></tr>
<tr><td>Split beams</td><td>Deploy at least 1 like all single beams to obtain back scattering cross section data for detectability modeling</td><td>Deploy at least 1 split beam like all other single beams to obtain back scattering cross section data for detectability modeling</td></tr>
<tr><td>Pulse repetition rate</td><td>≥14 pings/second</td><td>≥24 pings/second</td></tr>
<tr><td>Trace acceptance Criteria
Trace Characteristics
Noise around trace
Acceptable sample Range and time</td><td>≥4 echoes with a maximum 4 ping gap and ≤30 pings long
Light
70% of range and time trackable</td><td>≥4 echoes with a maximum 4 ping gap and ≤60 pings long
Light
>50% of range and time trackable</td></tr>
<tr><td>Direction of movement</td><td>None</td><td>Downstream toward spill gate and downward from 2.3 to 7 m range; flat or downward from 7-10 m range. Azimuth direction could be very wide (e.g., >180 degrees and <360 degrees where 270 degrees would be directly downstream toward the gate.</td></tr>
<tr><td>Transducers</td><td>Nominal 6-8 degrees</td><td>Nominal ≥10 degrees</td></tr>
<tr><td>Detectability modeling</td><td colspan="2">Model detectability (including any trace acceptance criteria), present all inputs and outputs, and describe in detail how results were used to adjust spatial expansions</td></tr>
<tr><td>Noise modeling</td><td colspan="2">Use a noise model to describe the fraction of time that could be tracked and use that information to discard poor samples with <50% trackable time and to expand fish counts based upon the fraction of time that was tracked.</td></tr>
<tr><td>Receiver gains</td><td colspan="2">Present table showing equalized receiver gains and other important calibration data and describe any significant changes in receiver gains between the preseason and postseason calibrations.</td></tr>
<tr><td>Data compendium</td><td colspan="2">In addition to figures and tables presented for interpreting results an appendix should be included that provides expanded fish counts by transducer and sampling range and includes all interpolations and hourly flow by turbine, sluice entrance, and spill bay. This appendix would assure that future assessments of meta data for John Day Dam have all fish passage and operations data to recalculate any metric. These data also should be provided on a compact disk or other media suitable for archival.</td></tr>
</table>

7.2.1.3 Survival

As mentioned earlier, smolt survival estimates for John Day Dam are limited and inadequate for making management decisions. A recommended course would be to continue evaluating project, dam and route-specific survival techniques to perfect the methods for use at John Day Dam forebay and tailrace as a whole.

7.2.2 Project Operations

The route-specific survival data that are currently available, is insufficient for identifying a specific operational scenario for juvenile salmonid protection. To date, information is available on intake screen performance, but data describing spillway passage efficiency and powerhouse passage is variable and inappropriate for identifying specific spill and turbine discharge patterns.

7.2.3 Specific Studies to Address Data Limitations and Uncertainties

As mentioned earlier, a range of fish guidance efficiency values has been identified for each stock migrating through John Day Dam. This information could be combined with additional radio telemetry, hydroacoustic, and mark-recapture evaluations to identify route-specific survival and efficiency estimates. The most important task may be to determine overall fish survival past the entire dam across typical operating scenarios currently specified within the Biological Opinion. If survival through the project or dam is acceptable, then additional specific information on spillway passage efficiency and vertical distribution may not be necessary.

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Appendix A

Annotated Bibliography

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Annotated Bibliography

We sorted references in this annotated bibliography by study type (hydroacoustics, radio telemetry, and survival), study year, and alphabetically by lead author to make the material readily accessible for readers with particular interests.

A.1 Fixed-Location Hydroacoustics

Moursund, R.A., K.D. Ham, B.D. McFadden, and G.E. Johnson. 2001. Hydroacoustic evaluation of downstream fish passage at John Day Dam in 2000. Draft final report to U.S. Army Corps of Engineers, Portland District, Oregon.

The objectives of the 2000 evaluation were to 1) estimate downstream juvenile salmon passage rates through the turbines, bypass system, and spill in relation to discharge and 2) estimate the differences in routes and timing of juvenile salmon passage between two spill regimes. Targeted daytime spill levels were 0 and 30% and a fixed 60% spill level at night (1900-0559 h). Due to generation requirements the blocked spill operation was not consistently achieved. Actual spill levels were 30% for day and 53% for nighttime spill. Passage was monitored hydroacoustically at Turbines 1-16 and Spill Bays 1, 2, 4, 7, 10, 13, and 16-20.

Mean daily spill efficiency was 94% for days with 30% spill and 64% for days with no spill. Spill effectiveness was 2.22 for days with 30% spill and 3.35 for days with no daytime spill.

Effective beamwidths were calculated by combining mean velocity and target strength with range with the system configuration parameters: ping rate, minimum number of echoes, beam width, aiming angle, trajectory by range, and target strength threshold.

Johnston, S.V., and P.A. Nealson. 2000. Hydroacoustic studies at John Day Dam during spring and summer 1999. Final report to U.S. Army Corps of Engineers, Portland District, Oregon. Contract No. DACW57-96-D-0007, Task Order No. 04, Objective Task No. 1. 33 pp. + app.

The primary objectives of the 1999 evaluation were to 1) estimate downstream-fish passage through the powerhouse and spillway to assess the efficiency of daytime spill and 2) use split-beam hydroacoustic techniques to provide fine-scale behavioral data on fish distribution, direction of movement and size. Targeted daytime spill levels were 0 and 30% and a fixed 60% spill level at night (1900-0559 h). Due to generation requirements the blocked spill operation was not consistently achieved. Actual spill levels were 30% for day and 45% for nighttime spill. Single-beam transducers were deployed at Turbines 1-3 and 5-16 and Spill Bays 2, 4, 5, 7, 8, 10, 11, 13, 16, 18, and 19.

Study results indicated that 30% daytime spill was significantly more efficient than 0% daytime spill on a 24-h basis for both spring and summer periods. Mean daily spill efficiency during spring was 82% for days with 30% spill and 68% for days with 0% spill. In summer, spill efficiency was 93% for days with 30% spill and 63% for days with 0% spill.

Study addresses detectability related to water velocity and ping rate and evaluates differences in target strengths at selected turbine and spillway locations. It appears that a single effective beamwidth was used over the entire sample range for a given transducer.

Ploskey, G.R., and T.J. Carlson. 1999. Comparison of hydroacoustic and net estimates of fish guidance efficiency of an extended submersible bar screen at John Day Dam. North American Journal of Fisheries Management 19:1066-1079.

The primary objective of this study were to 1) compare estimates of guided and unguided fish passage and fish guidance efficiency (FGE) of an extended submersible bar screen (ESBS) between hydroacoustic and net sampling techniques and 2) to describe seasonal and diel patterns in hydroacoustic estimates of fish passage and FGE.

Fish guidance efficiency data was collected concurrently using hydroacoustic and netting in intake 7B, during the spring and summer of 1997; National Marine Fisheries Service used a gatewell dipnet and fyke nets downstream of the ESBS in intake 7Bfor 1-3 h/d. Significant correlations were found between hydroacoustic and gatewell estimates of guided fish; between fyke-net and hydroacoustic estimates of unguided fish passage; and between hydroacoustic and net estimates of FGE when sampling was concurrent. Fyke-net data indicated a uniform lateral distribution of fish passage across the width of the intake for yearling chinook salmon in the spring and subyearling chinook salmon in summer. In spring and summer, similar numbers of juvenile salmon were captured in columns of fyke nets on the left, middle, and right columns of the intake. A strong diel pattern in distribution was observed with the highest passage rates occurring from 2000-0000 h in spring and 2100-0000 h in summer. Diel estimates of FGE were similar between day and nighttime periods in spring, but were significantly higher during the day (82%) than at night (62%) in summer. Estimates of FGE from netting and hydroacoustic efforts both showed a significant decline in FGE from spring to summer. This is a thorough comparison of FGE calculated concurrently by two sampling methods. Authors do a good job of identifying sources of bias in both hydroacoustic and netting techniques. Detectability of the hydroacoustic system was considered and evaluated as a possible source for the difference in passage estimates observed between the two methodologies. Analyses were appropriate to accomplish study objectives.

BioSonics, Inc. 1999b. Hydroacoustic study at John Day dam, 1998. Final report to U.S. Army Corps of Engineers, Portland District, Oregon. Contract No. DACW57-96-0005. 31 p.

Objectives of this study were to monitor passage of juvenile salmon through the powerhouse and spillway and 1) estimate powerhouse and spillway efficiency and effectiveness, and 2) describe horizontal, vertical, and diel distributions of smolt passage.

The study consisted of spring and summer periods. Powerhouse passage was monitored at Turbines 1c, 2a, 5c, 7c, 9c, 11a, 13b, and 15c. Juvenile fish passage was monitored at spill bays 1, 2, 4, 7, 10, 13, 16, 17, 18, 19, and 20. Mean spill efficiency during spring was 68% and ranged from 30%-97%; mean spill effectiveness was 2.1 and ranged from 0.5 to 5.9. Mean spill efficiency during summer was 57% and ranged from 8%-96%; mean spill effectiveness was 1.8 and ranged from 0.4 to 9.7. The majority of passage occurred through spill; spill bay passage rates were highest at bay 18. In general, passage was highest in the middle bays (7-12) and lower toward the north (spill bay 1) and south portions (spill bays 16 and 19). Passage through spill bays was surface oriented with a peak in passage occurring from 15 to 23 ft deep. Powerhouse passage was highest toward the southern end of the powerhouse; the vertical distribution of passage into turbines was skewed toward the intake ceiling. Turbine distributions were consistent between day and night periods. Daytime spill passage was high during the peak of the run and turbine passage was consistently greater at night. Data described above is from a Preliminary Report and does not incorporate project operations and as should be expected is short on descriptions of detectability determination and analyses.

BioSonics, Inc. 1999a. Hydroacoustic evaluation and studies at the John Day Dam, spring 1997, Appendices 1-6. Final report to U.S. Army Corps of Engineers, Portland District, Oregon.

The objectives of this study were to 1) estimate juvenile salmonid passage effectiveness of two spill bays with and without overflow weirs, 2) evaluate changes in the spatial and temporal distributions of juvenile salmon related to the presence of overflow weirs, and 3) estimate efficiency and effectiveness of each passage route (spillway, turbine, weirs).

Vertical distributions for spill bays 18 and 19 combined are presented for weir-in and weir-out treatment. Composite vertical distributions from the additional spill bays and turbines are included. At spill bays 18 and 19, fish were surface oriented with the weir in and out. However, passage rates during the weir-in treatment were approximately one-half those while the weir was out. In-turbine passage was highest toward the intake ceiling. Unfortunately, this report was in its preliminary stages. Tables of location specific discharge and passage estimates are provided, but efficiency and effectiveness values are not summarized.

BioSonics, Inc. 1996. Estimation of guidance efficiency of an extended bar screen at John Day dam by hydroacoustic techniques. Draft final report prepared for U.S. Army Corps of Engineers, Portland District, Oregon, 11 November 1996. 12 pp. + app.

The objectives of this study were to 1) obtain hydroacoustic estimates of fish guidance efficiency (FGE) for extended length submerged bar screens, and to 2) collect data for use in establishing the relationship between fyke net and hydroacoustic FGE estimates.

Overall average of FGE in spring was 0.92 ± 0.04 and was 0.75 ± 0.04 in summer. Fish guidance efficiency generally decreased from the spring to summer period. In-turbine and diel passage demonstrated a rapid increase in passage around 2000 h. Passage rates remained relatively high from 2000-0200 hrs and then decreased through early morning hours and remained low throughout the daytime period. Appears that the transducers monitoring guided fish passage differed in detectability. Fish guidance efficiency estimates varied depending on which pairing of transducers passage estimates were taken from.

McFadden, B. D., and J. Hedgepeth. 1990. Hydroacoustic evaluation of juvenile salmon fish passage at John Day dam in summer 1989. Final report to U.S. Army Corps of Engineers, Portland District, Oregon, 05 January 1990. Contract No. DACW57-80-C-0070. 107pp. + app.

The objectives of this study were to 1) estimate hourly passage of juvenile salmon through the powerhouse and spillway, 2) estimate spillway efficiency and effectiveness, 3) describe horizontal and vertical distributions of fish passage into the powerhouse and spillway, 4) determine weekly estimates of migrant salmonid target strength at the powerhouse and spillway using dual-beam techniques, and 5) compare hydroacoustic and airlift estimate of fish passage into one Turbine 3 intake. Hydroacoustic sampling was conducted from June 11 to August 23, 1989.

Overall, 85.5% of juvenile salmon passed through the powerhouse and 16.5% passed through the spillway. Passage through the powerhouse was highest through Turbines 1 and 7 which also had the most discharge compared to other monitored units. Passage through the spillway was highest through bay 20 which also had the highest discharge compared to other locations. Overall, the majority of fish entering the powerhouse were between 36 and 75 ft from the surface. The majority of fish detected at the spillway were between 26 and 49 ft deep. Passage into the powerhouse and spillway increased sharply at 2300 hrs, decreased gradually to 0500 hrs and decreased sharply between 0500 and 0600 hrs. Diel patterns of powerhouse passage were similar to the distribution observed for the entire project. Unfortunately, most of the metrics are presented as percentages instead of fish density.

Ouellette, D.A. 1988. Hydroacoustic evaluation of juvenile salmon fish passage at John Day dam in summer 1988. 1988. Final report of BioSonics, Inc. to the U.S. Army Corps of Engineers, Portland District, Oregon, 23 December 1988. Contract No. DACW57-88-C-0049. 64pp. + app.

The objectives of this effort were to use single- and dual-beam hydroacoustics to 1) estimate hourly passage of juvenile salmon through selected turbines and spill bays, 2) estimate spillway efficiency and effectiveness, 3) describe horizontal distribution of passage, and 4) estimate target strengths of the migrant population using dual-beam transducers at turbine and spillway entrance. From June 10 to August 15, spill was initiated if the 24-hr estimate of fish passage exceeded 30,000 migrants. When spill occurred, the spill gate(s) were open to spill 18% of the instantaneous project discharge. Data was collected from May 13 through August 15, 1988.

Spill efficiency for the season averaged 18.7% and spill effectiveness was 1.1 overall. The highest spill efficiency and effectiveness corresponded to the highest spill discharge. Overall, 90.3% of juvenile migrants passed through the powerhouse and 9.7% passed through spill. Powerhouse passage was highest through the southernmost turbines, which also had the most discharge. Spill typically occurred at either bay 20 and 19 or 19 and 18. The majority of passage and discharge occurred through bay 19. Overall, fish passed into the powerhouse within 50 to 98 feet from the surface. The distribution of fish became progressively deeper as the season progressed. Passage into the spillway was highest from 30 to

40 ft deep. Fish passage through the entire project increased rapidly during early hours of monitoring, peaking at midnight. Fish passage rates remained until the last hour of monitoring when they decreased sharply. The diel distribution of passage through the powerhouse was similar to the overall project distribution, unlike spillway locations where passage was relatively constant during hours of spill.

Johnson, L., and R. Wright. 1987. Hydroacoustic evaluation of the spill program for fish passage at John Day dam in 1987. Final report of Associated Fisheries Biologist, Inc. to U.S. Army Corps of Engineers, Portland District, Oregon, 31 December 1987. Contract No. DACW57-87-C-0077. 71pp. + app.

The objectives of the 1987 hydroacoustic effort were to 1) provide run timing information to coordinate spill with increased juvenile fish passage and to 2) describe horizontal, vertical, and temporal distributions of fish passage.

Overall spill efficiency and effectiveness were 22.6% and 1.3, respectively. Both efficiency and effectiveness values decreased during the last two weeks of the monitoring period. Spill efficiency was typically higher during the first four hours of night spill. Data collected while all six monitored turbines were on-line show that passage was slightly greater at Turbines 3 and 5 (19.5% and 19.1%, respectively) toward the south end of the powerhouse. Vertical distribution data is presented for powerhouse locations only. Fish passed deeper as the season progressed. Species composition data showed that subyearling chinook salmon were the predominant species late in the season and the STS also had low bypass efficiency of subyearlings. Variations in vertical distribution suggest screen effectiveness may vary by location and time period. Overall, during the nighttime monitoring period, passage increased rapidly during early evening, leveled off and then decreased sharply during the last hour of monitoring. There was little variation in passage rates through spill for nights when there was prolonged spill. Appendix on error, penned by Dr. Dick Thorne is included.

Kuehl, S. 1987. Hydroacoustic evaluation of juvenile salmon fish passage at John Day dam in summer 1986. Final report of BioSonics, Inc. to U.S. Army Corps of Engineers, Portland District, Oregon, 27 February 1987. Contract No. DACW57-86-C-0088. 61pp. + app.

The goals of this fixed-location hydroacoustic monitoring effort were to 1) provide real-time estimates of nighttime fish passage, 2) estimate spill efficiency and effectiveness, 3) describe horizontal distributions of fish passage at the powerhouse vertical distributions at the powerhouse and spillway, and to 4) describe seasonal and daily trends of fish passage.

The distribution of passage suggests it may be acceptable to monitor passage at the middle intake and then expand passage estimates to estimate total turbine passage. Fish density was higher at spillway than powerhouse locations, but data collected are from different temporal period and are therefore not directly comparable, due to potential differences in diel distributions. Vertical distributions of fish passage were fairly uniform among sampled turbines throughout the study period. Peak distributions generally occurred from 89 to 119 ft deep. During the daily period of hydroacoustic monitoring (2000-0500 hrs) total project passage (powerhouse and spillway combined) was highest from 0300-0400 hrs during Weeks 1 and 2. In Weeks 3-5, the peak in diel passage occurred in the evening (2100-2200 hrs) rather than the morning.

Magne, R.A., D.R. Bryson, and W.T. Nagy. 1987. Hydroacoustic monitoring of downstream migrant juvenile salmon at John Day dam, 1984-1985. U.S. Army Corps of Engineers, Portland District, Operations Division, Fisheries Field Unit, Bonneville Lock and Dam, Cascade Locks, Oregon, August 1987. 29pp. + app.

The objectives the hydroacoustic monitoring effort in 1984 and 1985 were to ensure effective use of spill for fish passage by making real-time projections of hourly fish passage. A juvenile bypass system constructed with Submerged Traveling Screens was initiated in 1984 and the first nine units were screened by the third week of the 1985 season. Hydroacoustic monitoring occurred from June 5 to August 26, 1984 and from April 21 to July 28, 1985.

In 1984, estimates of the percentage of passage occurring during the nighttime period range from 37.8% to 80%. In 1984, spill efficiency estimates ranged from 17.4% to 77% and spill effectiveness values ranged from 0.5 to 1.5. In 1985, spill efficiency estimates ranged from 4.5% to 49.3% and spill effectiveness values ranged from 0.43 to 2.1. No information is provided regarding horizontal, vertical, or diel distributions of fish passage. The effort successfully accomplished the objective of making real-time hourly passage estimates.

Magne, R.A., W.T. Nagy, and W.C. Maslen. 1987. Hydroacoustic monitoring of downstream migrant juvenile salmon at John Day dam in 1983. U.S. Army Corps of Engineers, Portland District, Operations Division, Fisheries Field Unit, Bonneville Lock and Dam, Cascade Locks, Oregon, 10 November 1987. 35pp. + app.

The objectives of the 1983 spring and summer hydroacoustic monitoring efforts were to 1) determine the timing of spills to increase smolt survival and conserve water, 2) estimate spill efficiency and effectiveness, 3) determine seasonal run timing 4) determine the horizontal, vertical, and temporal distribution of passage, and 5) determine the relationship between hydroacoustic and gatewell airlift passage estimates. Nighttime spill was requested when estimates of daily fish passage were 30,000 or greater. The "B" intake slots of turbines 1, 3, 5, 9, 13, 15, and 16 were monitored using fixed-aspect single-beam transducers. Fish passage was monitored at spill bays 12, 15, 16, 18, 19, and 20. Data was collected from 2000-0600 hrs PDT. Spill patterns evaluated were crowned (for adults), concentrated (for juveniles) and even (for juveniles).

Data suggested that spilling more than 50%of total project discharge during peak hours of nighttime passage is the most successful technique for passing juvenile salmon past the dam. Passage rates at the powerhouse were higher toward the south end during both spring and summer, though there was a slight shift toward the north during summer. Within spill bays that were monitored passage was highest at bay 18 during the spring migration and bay 17 during the summer migration. This distribution was observed during both the even and concentrated spill patterns. The depth distribution of fish was similar among monitored intakes. Fish were distributed deeper during summer than spring. Diel distributions of fish passage demonstrated an increase in passage rates at dusk, peaking between late evening and early morning the then dropped off sharply at dawn. A significant positive correlation (r=0.91, p , 0.001) was obtained between hydroacoustic and Turbine 3 airlift daily passage estimates.

Magne, R.A., W.T. Nagy, and W.C. Maslen. 1983. Hydroacoustic monitoring of downstream migrant juvenile salmon at John Day dam, 1980-1981. U.S. Army Corps of Engineers, Portland District, Project Operations Division, Fish Management Unit, Bonneville Lock and Dam, Cascade Locks, Oregon, February 1983. 75pp. + app.

The goal of the 1980-1981 hydroacoustic monitoring effort at John Day Dam was to synchronize spilling with prime passage times to maximize fish survival and conserve energy. Objectives of both the 1980 and 1981 efforts effort were to 1) demonstrate the ability of the side scan sonar to detect fish concentrations in the near forebay and at turbine and spill bay intakes, 2) characterize spatial and temporal fish passage distributions, 3) characterize fish passage vs. spill volume, pattern and duration, 4) determine effectiveness of sequential turbine load dropping to move fish to the spillway, 5) determine juvenile salmonid holding areas and upstream approach patterns, 6) develop techniques to quantify fish detected with sonar, 7) compare gatewell sampling with airlift sampling at Turbine 3, and 8) compare shallow spill net sampling at spill bay 16 with sonar. Additional objectives in 1981 were to 1) estimate daily fish passage through Turbines 3, 10, and 16 to develop run timing, 2) compare deep draft spill and shallow spill for fish passage effectiveness, and 3) provide spillway passage for juveniles to identify optimum time periods to selectively spill "non-surplus" water. Spill was requested when projected hourly passage estimates exceed 30,000 fish.

In spring 1981, the mean fish passage distribution was fairly even among monitored turbines. During summer 1981, passage was highest toward the middle of the powerhouse and about evenly divided between north and south extremities. Daily reversals in relative fish passage estimates were observed between north and south extremities. Reversals in passage between powerhouse extremities were more pronounced for the summer than spring outmigrants. In 1981, the turbine passage vertical distribution peak was 35 ft below surface and skewed toward the top of intake. The peak of the vertical distribution was 68 ft deep in spring compared to 85.6 ft in summer. In spring, the majority of passage (72%) occurred from 2000-0600 hrs during the first week of the study. At night, mean passage estimates peaked from 2200 to 2300 hrs with a rapid decline from 0500-0600 hrs. During summer, peak passage occurred from 0100-0200 hrs. Peaks in fish passage occurred between April 21 and May 5 and through June 10, 1981 for the spring outmigration period. The summer outmigration peaked the first week of August. Data collected at spill bays to test the ability to move fish toward the spillway using sequential load dropping of turbine units was insufficient. By today's standards, sampling effort would be considered inadequate (three of 16 turbines and two of 20 spill bays.

A.2 Radio Telemetry

Beeman, J.W., H.C. Hansel, P.V. Haner, and J. Hardiman. 2000 (Preliminary). Estimates of fish and spill passage efficiency of radio-tagged juvenile steelhead and yearling chinook salmon at John Day Dam, 2000. Annual report of Research, 2000, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: 1) determine the proportion of radio-tagged juvenile steelhead and yearling chinook salmon passing through the spillway and powerhouse (guided and unguided) at John Day Dam during 12 and 24 hour spill treatments and 2) obtain information on behavior of radio-tagged fish including: forebay approach, residence time, time of passage, and route of passage.

Methods, Key Results, and Data Quality Assessment: Radio-tagged yearling chinook salmon (n=484) and yearling steelhead (n=487) were released 23 km above the dam. The 12 h treatment consisted of 0% day spill and 60% night spill and the 24 h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 53%). Steelhead FPE was 93% during the 12-h treatment and 88% during the 24-h treatment. Yearling chinook salmon FPE was 84 and 90% during 12-h and 24-h treatments, respectively. None of the FPEs were significantly different. Steelhead SPE did not differ significantly between treatments but yearling chinook salmon SPE was significantly greater during the 24-h treatment than the 12-h treatment. Steelhead SPE estimates were 69 and 73% during the 12-h and 24-h treatments, respectively, and yearling chinook salmon SPEs were 66 and 83%. Spill effectiveness was greater during day spill than night spill and all values were greater than 1:1. Steelhead during day spill was 2.3:1 and yearling chinook salmon was 3.0:1. Sample sizes were high for a radio telemetry study. Coverage was very good with both aerial and underwater antennas with fast scanning DSPs. Detection (96%) was very high also.

Duran, I.N., T.L. Liedtke, L.S. Brown, J.M. Drzewiecki, D.E. O'Donoghue, J.A. Quenette, E.M. Shoudel, Jon Paul Anderson, and J. Beeman. 2000a (Preliminary). Movement, distribution and behavior of radio-tagged juvenile steelhead and yearling chinook salmon in the tailrace of John Day Dam, 2000. Annual report of Research, 2000, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: Determine tailrace egress and residence time of juvenile salmon passing different locations through the spillway and through the bypass outfall at John Day Dam during spring under conditions of 12 and 24-hour spill tests.

Methods, Key Results, and Data Quality Assessment: Radio-tagged yearling chinook salmon (n=144) and yearling steelhead (n=138) were released through spill bays 2, 10, 18, and the bypass outfall. The 12 h treatment consisted of 0% day spill and 60% night spill and the 24 h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 53%). For the tailrace tests the 0% condition was not tested. During 30% spill tests the mean residence times were similar for yearling chinook salmon from all release sites averaging about 10 min. During the 60% spill tests, however, the residence times of yearling chinook salmon released from the bypass was about 3 times longer than the fish released from the spill bays. For steelhead the fish released from the south bay 18 were consistently longer residence times than all other release sites for both 30 and 60% test conditions. Sample sizes good.

Duran, I.N., T.L. Liedtke, L.S. Brown, J.M. Drzewiecki, D.E. O'Donoghue, J.A. Quenette, E.M. Shoudel, Jon Paul Anderson, and J. Beeman. 2000b (Preliminary). Movement, distribution and behavior of radio-tagged juvenile subyearling chinook salmon in the tailrace of John Day Dam, 2000. Annual report of Research, 2000, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: Determine tailrace egress and residence time of juvenile salmon passing different locations through the spillway and through the bypass outfall during 12- and 24-hour spill tests.

Methods, Key Results, and Data Quality Assessment: Radio-tagged subyearling chinook salmon (n=150) released through spill bays 2, 10, 14, and the bypass outfall. In 2000 tests were conducted at John Day to determine spill and fish passage efficiency during 12 h and 24 h treatments. The 12 h treatment consisted of 0% day spill and 60% night spill and the 24 h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 53%). For the tailrace tests the 0% condition was not tested. Subyearling chinook salmon released from the bypass had the highest tailrace residence times during both 30 and 60% spill conditions. Generally, the mean residence times of all subyearlings released from the spill bays were not significantly different between the 30 and 60% tests. Fish released from the bypass during 30% spill had significantly lower mean residence times than bypass fish during 60% spill. Sample sizes fair.

Giorgi, A.E., L.C. Stuehrenberg, D.R. Miller, and C.W. Sims. 1985. Smolt passage behavior and flow-net relationship in the forebay of John Day Dam. Final report of research, 1985. Bonneville Power Administration (DE-A179-84BP39644), Portland, Oregon, and the National Oceanic and Atmospheric Administration, Seattle, Washington. 184 pp.

Objectives: Define the migration routes of downstream migrant juvenile salmon in the forebay of John Day Dam, evaluate if forebay current patterns and velocities affected migration routes, and evaluate the effectiveness of spill for bypassing outmigrant salmon.

Methods, Key Results, and Data Quality Assessment: In 1983, 34 radio-tagged juvenile salmon were individually boat-tracked from a release site 6.3 km above the dam down to the dam. Four fixed monitoring stations were located on the dam to check for fish lost by boat tracking. In 1984 individual tracking was abandoned and larger group releases yearling chinook salmon were made (3 groups of 28 and 1 group of 11 fish) to better evaluate spill effectiveness. The plume of the John Day River affected juvenile salmonid distribution as they approached the forebay to either avoid the plume or be swept toward the Washington shore and enter the forebay toward the spillway. Fish arriving during the day delay and pass at night; fish arriving at night pass with little delay. There is no evidence to suggest that juvenile salmon approaching the dam alter their migration routes in response to current pattern in the forebay. In 1983 over 90% of the yearling chinook salmon passed the spillway when spill averaged 50% of the river flow. In 1984, 74% of the yearling chinook salmon passed through the spillway when the spill averaged 42% of the river flow. Sample sizes very low, monitoring array limited. An early study but thorough considering the “state of the art”.

Hansel, H.C., R.S. Shively, G.S. Holmberg, T.P. King, and M.B. Sheer. 1995. Movements and distributions of radio-tagged northern squawfish near The Dalles and John Day dams. In Poe, T. P. (ed.) Significance of selective predation and development of prey protection measures for juvenile salmon in the Columbia and Snake river reservoirs. Annual Report of Research, 1993 (DOE/BP-91964-4) by the National Biological Survey to the Bonneville Power Administration, Portland, Oregon.

Objectives: The behavior and distribution of 71 radio-tagged northern pikeminnow were monitored from May through September, 1993 in the tailrace of John Day Dam to acquire information to aid in establishing biological criteria for optimum location of juvenile bypass outfalls and to examine modes of project operation that may potentially reduce predation in tailrace areas of dams.

Methods, Key Results, and Data Quality Assessment: Radio-tagged fish were monitored with fixed receiver stations and frequent mobile tracking. Northern pikeminnow used areas away from the spillway stilling basin during periods of high spill (mostly in May) but switched to frequent areas in the spill basin and at the powerhouse in July and August when subyearling chinook salmon were abundant and dam discharges were reduced. Most spill occurred at night; about twice as many predators were contacted at night than during the day. Of all position fixes of predators in the tailrace through the season, fewer than 1% occurred within a radius of 200 m downriver of the bypass outfall. Detection % was 89% for tagged fish released outside the BRZ and 94% for fish released inside the BRZ.

Hansel, H.C., J.W. Beeman, T.D. Counihan, B.D. Liedtke, M.S. Novick, and J.M. Plumb. 2000a. Estimates of fish and spill passage efficiency of radio-tagged juvenile steelhead and yearling chinook salmon at John Day Dam, 1999. Annual Repot of Research, 1999, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: 1) determine the proportion of radio-tagged juvenile steelhead and yearling chinook salmon passing through the spillway and powerhouse (guided and unguided) at John Day Dam during 12 and 24 hour spill treatments, and 2) obtain information on behavior of radio-tagged fish including: forebay approach, residence time, time of passage, and route of passage.

Methods, Key Results, and Data Quality Assessment: Radio-tagged yearling chinook salmon (n=469) and yearling steelhead (n=479) were released 23 km above the dam. Fixed stations were used to monitor turbine units, tainter gates, and the juvenile bypass system. The 12 h treatment consisted of 0% day spill and 60% night spill and the 24 h treatment consisted of 30% day spill and 60% night spill (actual night spill averaged 45%). Steelhead FPE was 94% during the 12-h treatment and 90% during the 24-h treatment. Yearling chinook salmon FPE was 82 and 87% during 12-h and 24-h treatments respectively. None of the FPEs were significantly different. Steelhead SPE did not differ significantly between treatments but yearling chinook salmon SPE was significantly greater during the 24-h treatment than the 12-h treatment. Steelhead SPE estimates were 45 and 53% during the 12-h and 24-h treatments, respectively, and yearling chinook salmon SPEs were 53 and 66%. Sample sizes were high for a radio telemetry study but loss of the fourth block of data reduced the power of the tests to detect differences in FPE and SPE. Coverage was very good with both aerial and underwater antennas with fast scanning DSPs. Detection % was very high also.

Hansel, H.C., J.W. Beeman, T.D. Counihan, B.D. Liedtke, M.S. Novick, and J.M. Plumb. 2000b. Movement, distribution, and behavior of radio-tagged subyearling chinook salmon in the forebay of John Day Dam, 1999. Annual Report of Research, 1999, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: 1) determine the proportion of radio-tagged juvenile subyearling chinook salmon passing through the spillway and powerhouse at John Day Dam during 12 and 24 hour spill treatments and 2) obtain information on behavior of radio-tagged fish including : forebay approach, residence time, time of passage, and route of passage.

Methods, Key Results, and Data Quality Assessment: Radio-tagged subyearling chinook salmon (n=298) were released 23 km above the dam. The 12 h treatment was to consist of 0% day spill and 60% night spill and the 24 h treatment to consist of 30% day spill and 60% night spill, but none of the spill levels were met. Daytime spill at volumes occurring in 1999 appeared to increase the over-all 24-h spill passage of subyearlings. During blocks 1 and 2, 44 and 58% of the fish passed through the spillway during daytime no spill and daytime spill, respectively, while the remaining 56 and 42% of the fish passed through the powerhouse (guided or unguided). During block 3, 50 and 78% of the fish passed through the spillway during day no spill and daytime spill, respectively, while 50 and 22% of the fish passed through the powerhouse. Most fish (70%) arriving during periods of spill passed during the same diel conditions that were present when they arrived, but 55% of the fish arriving during days without spill delayed passage until night. Digital transmitters were not available for the subyearlings so FPE could not be measured. Detection was 54% -low.

Hensleigh, J.E., R.S. Shively, H.C. Hansel, J.M. Hardiman, G.S. Holmberg, B.D. Liedtke, T.L. Liedtke, R.E. Wardell, R.H. Wertheimer, and T.P. Poe. 1999. Movement, distribution, and behavior of radio-tagged juvenile chinook salmon and steelhead in John Day, The Dalles and Bonneville dam forebays, 1997. Annual Report of Research, 1997, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: Determine: 1) the general behavior, distribution, and approach patterns of radio-tagged juvenile salmon upriver and in the forebay areas of JDA, TDA, and BON; 2) the behavior of juveniles once inside the near-dam forebay area; 3) time and route of passage; and 4) the changes in behavior of fish associated with tests of surface bypass concepts and prototype surface bypass structures.

Methods, Key Results, and Data Quality Assessment: At John Day Dam overflow weirs were tested as a surface skim bypass concept for efficiency of fish passage in spill bays 18 and 19. Radio-tagged yearling chinook salmon, yearling steelhead and subyearling chinook salmon were released above the dam. Spill discharge ranged from 8 to 47% in spring and from 14 to 25% in summer. In spring steelhead and yearling chinook salmon approached the forebay of the dam by primarily moving downriver along the north side of the main channel. In summer the subyearlings moved downriver along both shorelines. The majority of first detections in the near dam forebay were at the spillway. Monitoring within the near dam forebay indicated that smolts were concentrated in the south end of the powerhouse. Lateral movements were observed for many fish. Residence times (medians) were 0.3-h for yearling chinook salmon, 0.5-h for steelhead, and 3.0-h for subyearling chinook salmon. The spillway passed 64% of yearling chinook salmon, 55% of the steelhead, and 50% of the subyearling chinook salmon. Test results of the overflow weirs indicated that the distribution of passage did not differ for any of the species across the project when the weirs were in place. 88% of spring migrants detected and 84% of summer migrants. DSPs used for weir tests but screens bypass not covered so FPE could not be determined.

Holmberg, G.S., R.S. Shively, H.C. Hansel, T.L. Martinelli, M.B. Sheer, J.M. Hardiman, B.D. Liedtke, L.S. Blythe, and T.P. Poe. 1997. Movement, distribution, and behavior of radio-tagged juvenile chinook salmon in John Day, The Dalles, and Bonneville dam forebays, 1996. Annual Report of Research, 1996, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: Determine: 1) the general behavior, distribution, and approach patterns of radio-tagged juvenile salmon upriver and in the forebay areas of JDA, TDA, and BON; 2) the behavior of juveniles once inside the near-dam forebay area; 3) time and route of passage; and 4) the changes in behavior of fish associated with tests of surface bypass concepts and prototype surface bypass structures.

Methods, Key Results, and Data Quality Assessment: At John Day Dam no specific tests of surface bypass concepts were conducted in 1996. Radio-tagged yearling chinook salmon (n=138) and subyearling chinook salmon (n=75) were released above the dam. Spill discharge ranged from 17 to 32% in spring and from 12 to 20% in summer. In spring yearling chinook salmon approached the forebay of the dam by primarily moving downriver along the north side of the main channel. In summer the subyearlings moved downriver in the same pattern. The first detections in the near dam forebay indicated that both yearlings and subyearlings were evenly dispersed as they entered the near dam area. Monitoring within the near dam forebay indicated that smolts were concentrated in the south end of the powerhouse. Lateral movements were observed for many fish. Residence times (medians) were 0.8-h for yearling chinook salmon and 2.3-h for subyearling chinook salmon. The most efficient route of passage was the spillway passing 42% of yearling chinook salmon with spill ranging 17 to 32% during passage dates and 40% of the subyearling chinook salmon with spill ranging from 12 to 20% during passage dates. 90% of spring migrants detected and 86% of summer migrants. Screens and bypass not covered so FPE could not be determined. Sample size moderate.

Liedtke, T.L., H.C. Hansel, J.M. Hardiman, G.S. Holmberg, B.D. Liedtke, R.S. Shively, and T.P. Poe. 1999. Movement, distribution, and behavior of radio-tagged juvenile salmon at John Day Dam, 1998. Annual Report of Research, 1998, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

Objectives: Determine tailrace egress and residence time for radio-tagged juvenile salmon passing the spillway through north, south, and mid bays at John Day Dam.

Methods, Key Results, and Data Quality Assessment: Radio-tagged yearling, and subyearling chinook salmon and yearling steelhead were released through spill bays 2, 10, and 18 at John Day Dam and monitored through the tailrace to an exit station 5.3 km downriver. River conditions did not vary significantly during spring or summer. Drogues released through the same spill bays had similar residence and travel rates as fish. About 10% of the subyearling chinook salmon appeared to be depredated by fish.

Sheer, M.B., G.S. Holmberg, R.S. Shively, H.C. Hansel, T.L. Martinelli, T.P. King, C.N. Frost, T.P. Poe, J.C. Snelling, and C.B. Shreck. 1997. Movement and behavior of radio-tagged juvenile spring and fall chinook salmon in The Dalles and John Day dam forebays, 1995. Annual Report, 1995 to the Army Corps of Engineers, Portland District, Portland, Oregon.

Objectives: This was a study to determine the feasibility of collecting detailed passage behavior data of radio-tagged juvenile salmon in the forebays of John Day and The Dalles dams. Specific objectives of the study were to examine: 1) distribution and approach patterns of radio-tagged juvenile salmon upriver of both dams, 2) the behavior and distribution of fish once inside the near-dam forebay in relation to dam operating conditions and hydraulic environment, and 3) time and route of passage.

Methods, Key Results, and Data Quality Assessment: From May 2 to June 8 seven groups of yearling chinook salmon were radio-tagged and released 8 km above John Day Dam. Tagged fish were monitored from the release site to the restricted zone of the forebay and then monitored with an array of aerial antennas connected to fixed station receivers. River flow ranged from 250-296 kcfs, spill ranged from 8-13 kcfs and averaged 3.9%. Downriver migration patterns followed 2 patterns with 3 groups moving downriver along the Washington shore and 3 groups moving downriver mid-channel. Almost all fish avoided the John Day River plume. A majority (~70%) of the tagged fish first entered the near dam forebay in the powerhouse area. Once inside the near dam forebay fish concentrated at the south end of the powerhouse and mean residence time before passing was 10.3-h. They estimated that 24% of the radio-tagged fish passed through the spillway and 76% passed through the powerhouse (unguided plus guided).

Shively, R.S., M.B. Sheer, and G.S. Holmberg. 1995. Description and performance of an automated radio telemetry system to monitor the movement and distribution of northern squawfish at Columbia River dams. In Poe, T.P. (ed.) Significance of selective predation and development of prey protection measures for juvenile salmon in the Columbia and Snake River reservoirs. Annual report of research, 1993 (DOE/BP-91964-4). Bonneville Power Administration, Portland Oregon.

Objectives: To develop, test, and describe an automated data-logging radio-telemetry system that was capable of monitoring northern pikeminnow movements within the boat restricted zone of dam tailrace areas. Test objectives were to 1) determine the efficiency and reliability of information collected by fixed site receiver stations, 2) compare results obtained with fixed stations to data collected by mobile tracking methods and determine the benefits and limitations of each method of data collection, and 3) determine the area within the range of the fixed receivers where northern pikeminnow were most likely to be located with positions estimates obtained by mobile tracking.

Methods, Key Results, and Data Quality Assessment: Seven fixed stations with a total of 34 Yagi antennas and 16 coaxial cable antennas were set up at John Day Dam. Radio transmitters were digitally-encoded and frequencies were spaced 20 KHz apart from 149.820-150.000 MHz. Receivers were programmed to sequentially scan individual antennas for each frequency, within ~4min. System testing consisted of tuning antenna gains related to noise floor to reduce possibility of noise affecting ability to record fish activity. Additional testing was done in the field by comparing mobile tracking data with fixed station data. Fixed receiver efficiencies were calculated by comparing the number of observations where fish were recorded by both methods, divided by the total number of mobile records in the zone of coverage. The number of individual fish contacted by fixed stations was not significantly different from mobile tracking when both methods were conducted simultaneously (Wilcoxen paired-sample test, John Day P=0.885). The advantage of fixed station systems was that continuous monitoring of fish could be achieved, but the disadvantage was that only general movements are recorded. Mobile tracking provided more precise position data but relatively few data points per fish could be obtained. Recommendation is to use a combination of both techniques.

Snelling, J.C., and C.B. Schreck. 1995. Movement, distribution, and behavior of juvenile salmon passing through Columbia and Snake river dams. Oregon Cooperative Fishery Research Unit, Oregon State University. <u>In</u> Poe, T.P. (ed.) Significance of selective predation and development of prey protection measures for juvenile salmon in the Columbia and Snake river reservoirs. Annual Report of research, 1993 (DOE/BP-91964-4). Bonneville Power Administration, Portland Oregon.

<u>Objectives</u>: To examine tailrace egress and residence time of juvenile salmon released through the John Day Dam bypass outfall.

<u>Methods, Key Results, and Data Quality Assessment</u>: They released a total of 89 radio-tagged yearling chinook salmon in small groups on ten dates from April 21 – June 9, 1993. For each group release, about one-half the fish were released through the bypass outfall and the other half were released as a control/reference in the river just below/at the outfall exit. They found no significant difference in residence time or route of passage down to an exit monitoring station 5.2 km below the dam (exit times ranged from 48 to 89 min). Only 2 of the 89 fish held/delayed at a point 4.5 km down from the dam and exited in a normal manner consistent with normal migration. River Q ranged from 160 to 326 kcfs during releases and only during 2 of the release dates, May 12 and 14, did spill occur (100 kcfs) and it appeared to have no real effect on residence times or routes taken. Sample sizes small, detection good (95%).
Survival

Counihan, T.D., J.H. Petersen, N.S. Adams, R.S. Shively, and H.C. Hansel. 2000. Feasibility of extracting survival information from radio telemetry studies at the John Day Dam. Annual report of Research, 1999, by the U.S. Geological Survey to the U.S. Army Corps of Engineers – Portland District.

<u>Objectives</u>: To examine the feasibility of extracting survival information from radio-telemetry studies of juvenile steelhead and yearling chinook salmon released during fish passage efficiency studies at John Day and The Dalles dams in 1999.

<u>Methods, Key Results, and Data Quality Assessment</u>: Survival probabilities were estimated using the release/recapture models of Burnham et al. (1987). Using radio-tagged yearling chinook salmon and steelhead to estimate survival probabilities is feasible and resulted in the following relative survival estimates: steelhead=0.93 (SE 0.38) and yearling chinook salmon=0.99 (SE 0.03) from Rock Creek to the release location of control fish in the tailrace of John Day Dam. However, they indicated that revisions to the current study design and tagging protocols would need to be done in the future to ensure that the assumptions of the survival models are satisfied.